Electrical Intelligence and Power—A Trusteeship

An Address By Walter P. Marshall
President, The Western Union Telegraph Company
AIEE Diamond Jubilee Celebration
Hotel Astor, New York, May 13, 1959

THE American Institute of Electrical Engineers was founded in this city of New York 75 years ago this very day. From that moment its members, whether they realized it or not, became the custodians of one of the greatest economic and socializing forces extant in the world today — electricity.

The record of your past transactions discloses how well the founders, and you who have succeeded them, have accounted for your stewardship. The sheer force which you have tamed has multiplied thousands of times the power of man's right arm. The lightning vibrations which you have put under precise control have projected man's intelligence — his mind and will — instantly to, and today beyond, the ends of the earth.

AIEE's twin concerns — for the generation and use of power, and for the communication of intelligence — can be traced from the very beginnings. I appreciate your kind invitation for me to help you celebrate your Diamond Jubilee. Western Union has had a strong interest in the AIEE throughout its 75 years and, as your program today notes, the first president of AIEE — Norvin Green — was also one of my predecessors in the presidency of Western Union. Telegraphy was the first application of electricity to emerge from the physics laboratory and assume crucial importance in the conduct of this nation's and the world's affairs. It had been established as a going industry some 40 years when AIEE was formed. In 1884, by contrast, the first commercial telephone exchange, at New Haven, was only six years old. Edison's pioneering Pearl Street generating station had not yet celebrated its second anniversary. Under such circumstances it is hardly surprising that, of the 25 men who signed the call to the original AIEE organization meeting of May 13, 1884, twenty-one including Edison were connected with the telegraph business.

Perhaps in contrast to Green, I have to disclaim any personal connection with engineering except that which rubs off on me by daily contact with engineers. My formal training was in accountancy. But the distinction need not be labored. Under the American system of free enterprise, business and engineering team up ideally in harness. We all bend our backs to the same load. We share a common responsibility to the public. Ours is a joint trusteeship. Both as to electrical power and electrical communication, modern utilities and manufacturing have had to learn to adjust to the strains produced by a rampant technology, just as engineering has had to learn to function within the constraints of the marketplace. So there is much interdependence between us and, I will venture, mutual respect.

IMPACT OF WAR

That makes me bold to mention certain matters which should interest engineers because they interest businessmen. For example, there is the impact of war. Including preparation for World War II and its aftermath, there has been a preoccupation with military matters for a period of 20 years. The future is going to depend greatly upon how long this posture of defense is to be continued. The government is engineering's biggest customer, and more fundamentally still, a prime mover of its developments, an arbiter of its laboratory projects, and a competitor for its scientific manpower.

Then there are the Russians, and an awareness here in the United States of their recent rate of progress. The range and complexity of American engineering have received fresh and sudden impetus

Dr. Norvin Green, fifth president of Western Union

from the linking of a necessity to achieve with a laudable objective to survive. The latest phase of the cold war resides more in the realm of technology than in that of liberal arts. This has shifted prime responsibility for results squarely upon science, engineering, and the business organizations which foster them. We enter the future shouldering this mutual burden.

But if our outstanding problems are great, so are our resources. Significance is to be attached to a gradual, fairly recent blurring of the stark lines which heretofore segregated electrical development into compartments, such as one for the transport of power and a separate one for the communication of intelligence. Your Institute is broad enough to include both. It has put electronics to work as advantageously in mercury-arc rectifiers as in radio receivers. It can foster a give-and-take across this old artificial boundary, to the profit of both sides. The world has already entered a domain where electrical mind is controlling electrical muscle in the most delicate demonstrations of automation.

An illustration of this was one of the wartime contracts my company carried out for the armed forces. We developed in our laboratories a simulated night-fighter training aid, consisting of a realistic airplane cockpit, complete with sound-effects and vibration, under a dome representing the sky. The trainee, with control of his plane's flight and gunfire, pitted himself against an enemy plane, first located by radar, then made apparent by a swiftly enlarging image on the dome, coming right at him, projected by a device not unlike those used in planetariums. Backstage, an analog computer arrangement figured out relative positions of the two opposing fighters in three-dimensional space, and gave the correct answers as to whether the fighter's gunfire reached target or by how much it missed. Nowadays that simulator has become the real thing. We have SAGE and NIKE — massive, powered gun-director and fighter systems actuated by

Western Union flight trainer with projector

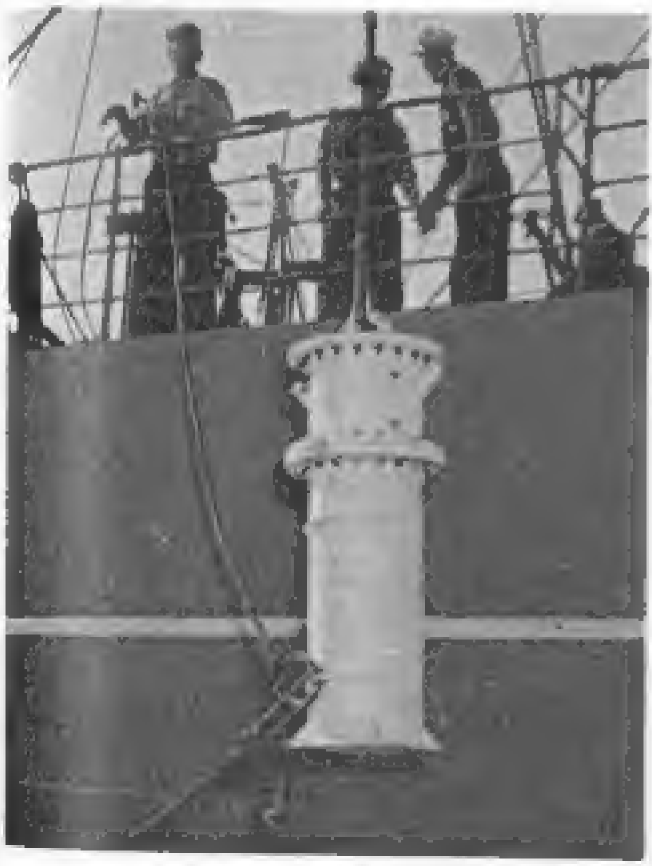
telegraph pulses picked up by a radar interception of the enemy. Here indeed is electrical power and intelligence teamed in double harness.

You engineers recognize a thread of

unity running throughout electrical communication, and you are witnesses (where you are not, indeed, the authors) of the breaking down of technical barriers which were erected during the communication industry's infancy. Frequency modulation, for example, was originally employed to eliminate static from received radio signals. However, in the telegraph business the value of the arrangement for use in minimizing crosstalk between adjacent wires on pole lines and in multipair cable was quickly recognized; and in 1939 frequency modulation became the Telegraph Company's standard for carrier transmission. Facsimile, too, shows up in various communication applications, but nowhere to better effect than in handling telegrams and in facsimile wire systems leased to users.

Electronic amplifiers were applied at the ends of submarine telegraph cables as early as 1924, and Americans were first to submerge intermediate, shore-powered amplifiers in ocean depths (1950) to speed up transatlantic cables. Telegraphy was first in the United States to establish intercity microwave radio transmission (1945), and has joined with telephony in giving wide employment to this economic mode of transmission. Without electronics the newer systems being utilized to transmit data at high speeds and with requisite accuracy could not be made available. The Telegraph Company, like others, is seeking to take advantage of modern devices like Masers and parametric amplifiers, which our engineers tell me are typical of today's tools that will become basic to tomorrow's operating systems.

Walter P. Marshall, new president of Western Union



Ocean cable submerged repeater of 1950

In this electronic and nucleonic age, technical developments by engineers in any industry may well prove useful to many others. Numerous interrelationships between companies have been brought about for this reason. For example, Western Union has invested in seven companies active in the electronics and allied fields as part of a program of selective diversification, and to supplement our own research and development activities. Among these companies are Microwave Associates, Technical Operations, Dynametrics, Hermes Electronics, Inc. (formerly Hycon Eastern), and Gray Manufacturing, which

include in their activities such diverse items as computer design, gamma ray projectors, magnetrons, varactor diodes, a nuclear fall-out monitor, and parts used in ICBM's and space satellites. And, of course, the prompting device I am using is one of various products and services of TelePrompTer Corporation, another company in which Western Union has acquired an interest. A major consideration in acquiring an interest in these companies has been the mutual benefit that results from close cooperation between their highly skilled engineers and ours on research and development, engineering and manufacturing problems.

TELEGRAPHIC AUTOMATION

Only a few years ago the telegraph business was almost exclusively concerned with transmitting intelligence as *language*. Today, nonlanguage telegraph signals are assuming importance. By means of binary or ordinary on-off signals, accumulated, stored, or sampled information controls machines, sometimes at great distances. Hence we have automation applied in factory production, and automation applied to business operations.

For years we have been storing telegraphed words briefly in strips of paper tape by means of punched holes, without thinking of such tapes as memories. But such they are, and their kinship to punched cards used in busines machines suggested that the information stored in cards could be converted for storage in tapes, and vice versa. From this it was only a step before we were really telegraphing our punches. Now every night, the timecards punched by Western Union employees in various cities in the United States are telegraphed into key centers where the time-clock notations are translated, in a couple of jumps, into pay checks. At the same time, and with the same data, the significant figures of hours, units of work, and pay are extended onto reports that disclose production and cost levels for management control purposes. The same methods of data processing are used, on many private wire systems we lease to industry, to give managements of highly decentralized organizations the information required for daily centralized control.

This all started with a dawning realization, about 20 years ago, that arithmetic could be performed on two fingers as easily as on ten; hence that the open and closed positions of an ordinary telegraph relay, or switch, or vacuum tube, could be used for full control of calculating machines.

We telegraph people were glad to contribute teleprinters and digital techniques to the pioneering models of computers, built in 1945. It was not long before the computer folks on a local basis were doing flip-flops (as they like to call it) away up in the kilocycles per second, and read-outs at the rate of a whole line of typewritten copy at a time. It is natural that communicators have a deep interest in computer techniques. For example, Western Union's most recent electronic switching complex makes great use of stored program computer techniques to attain flexibility, versatility and higher efficiency of operation.

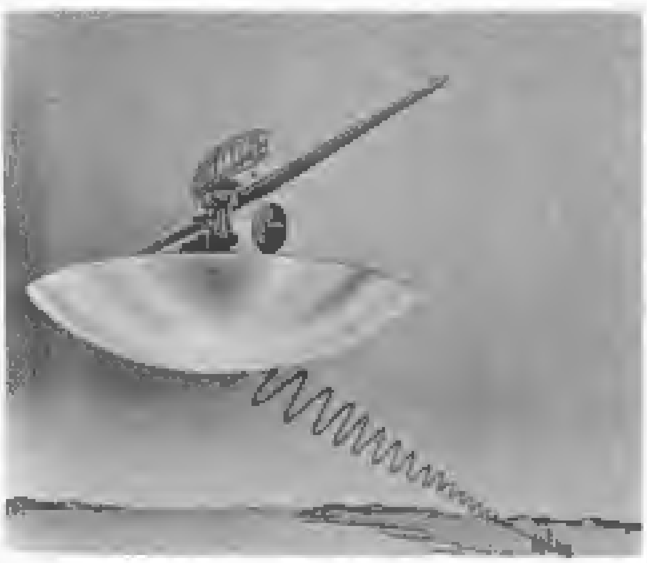
One can hardly overestimate the potentialities of the sensing, memory, discrimination, logic, and other thought-processes being built into modern computers. Already great progress is being made in this field. Our engineers are working now on what they believe will be the world's fastest and most advanced digital communication system; a private wire system to be used exclusively for transmitting data and capable of handling about 2,000,000 punched cards a day, or more than 90 million words.

I am glad to inform you that we have just been notified by the U. S. Air Force of their decision to proceed with negotiations with my company for the provision of the initial centers for such a system as I have just described. While the details will necessarily have to be worked out, it is anticipated that this will be the most important system Western Union has ever provided, from the standpoint of leased wire revenues, as well as from a national defense standpoint.

We can expect private wire systems of the future to be equipped with machines and systems that will respond to spoken

direction. Such systems will be engineered so that they will be capable of transmitting digitized voice, facsimile and other arbitrary data. This means that the system will have equipment so designed that a person can talk and the device will recognize words, interpret them into digits suitable for wire transmission and then, at destination, translate the digits into written language, or record them for processing by business machines and computers.

The entry into business of machines which can effectively complement human clerical endeavor will have a radical effect on the tempo, volume, and efficiency of business. The more common these sophisticated machines become, the greater the number of complex problems that will be presented to them to solve. Probability problems, problems involving the social and economic sciences — why we behave like human beings — will yield to these machines. Problems involving trial and error, and the comparative worth of alternative methods — operational research — will come within the range of solution, where up to now their complexity has defied solutions.



Space satellite as envisaged by Raytheon Company

It is only a step from what we have now into space—and nowadays, it seems, the sky's the limit. In the future, we may expect the military to have a whole network of satellites for the purpose of providing communications between any points on the surface of the earth, including the polar regions. These satellites will really be giant switchboards in the sky, capable of transmitting thousands of messages to U. S. Armed Forces around the world—instantly.

One, however, does hesitate to take both feet off the ground. After all, business and engineering have obligations to present customers which are not to be lost sight of. Much of what we continue to do must be for bread and butter, not pie-in-the-sky.

"THE PAST IS PROLOGUE"

But no one in a busines founded on engineering is neglecting participation nowadays in the opportunities being opened up in the atom and the cosmos. For the extent to which the past will prove to be prologue to the future of electrical engineering is to be judged by the astonishing progress being recorded today, in and above the stratosphere, and within the environments of fission and fusion. Your technology holds nothing more promising than the prospect of putting the atom to work in the generation of electricity, either through, or bypassing, the steam cycle—unless, indeed, it is the coordination of intelligence and power through which man will enter and explore the fastnesses of space.

In both spheres your members and our industrial concerns are eager participants and worthy trustees. As Edison, in his incandescent lamp, found a way to "subdivide the arc-light," so members of your Institute some day will find many ways to subdivide the energy unleashed by the atomic bomb.

And I feel equally confident that out of our radar bombarding of the moon and Venus, out of our transmission of measurement-data and intelligence across vast interplanetary distances, out of the precision of our control of space vehicles and satellites, will come a stream of contributions to the peace, satisfactions, and welfare of mankind.

In the pat translation of the Washington taxicab driver, the inscription in stone reminding the passerby that "The Past Is Prologue" really does mean "You Ain't Seen Nothin' Yet!"

ALBERT BOGGS, Assistant to Transmission Engineer

J. EDWIN BOUGHTWOOD, Transmission Engineer

Application of Telegraph Techniques in Data Transmission

The burgeoning of electronic computers as business machines has fostered increasing need of rapid interplant and intercity data transmission for which, as is well known, many conventional telegraph techniques are readily adaptable. Important new telegraph equipment items for data circuitry are carrier transceivers, loop transceivers and network repeaters.

DEVELOPMENT of a transmission system, or systems, to handle data on a nationwide basis requires first a knowledge of the various types of service that may be required. It may not be possible to foresee all potential requirements at the present state of the art but at least some are clearly indicated. Two of these are:

1. Point-to-point service, intracity or intercity, either private wire or shared facilities.
2. Multipoint service, usually private wire, such as ticket reservation or the bookkeeping applications of large corporations.

Point-to-point service for private wire customers poses no serious problems and can be provided in a straightforward manner once the speed of operation has been determined. Shared facilities, such as the use of an intercity circuit by several patrons in each city, introduce some complications. Manual or automatic switching between local patron facilities and the intercity circuit must be provided. For multipoint service, where groups of patrons in different cities must be able to interchange data information, still more complicated mechanisms are required.

Carrier Equipment

The Telegraph Company has for a number of years supplied data handling circuits engineered to fit in with its standard telegraph plant. These circuits have operated at speeds that allowed them to be assigned to narrow-band 75-baud carrier channels normally used for teleprinter service. Planning in respect to higher speed comprehensive data systems has been influenced by experience with these lower speed circuits and by consideration of transmission rates likely to represent the largest immediate use. At the same time compatibility with the present carrier telegraph plant has been preserved.

It is standard practice in the Telegraph Company to divide a voiceband into two subbands each capable of carrying ten telegraph channels spaced at 150-cycle intervals. By assigning the frequency space occupied by two adjacent telegraph channels to a single data channel a spectrum width adequate for 180 bauds is made available. This is the bit rate required by the 11-card-per-minute IBM transceiver and represents the most common demand of commercial users of data equipment at the present time. Equipment for two such channels, one centered at 1050 cps and the other at 1350 cps, is now available.

For rates higher than 180 bauds the entire subband spectrum (300 to 1800 cps) is utilized. The carrier equipment developed for this service is capable of operating at a maximum rate of 1000 bauds. Provision of equipment for rates higher than 1000 bauds is not at present contemplated. However, circumstances are envisioned wherein it may be preferable to abandon the subband and position the

A paper presented before the Winter General Meeting of the American Institute of Electrical Engineers in New York, N. Y., February 1959.

1000-baud system in an optimum region of a whole voiceband. This can easily be done with the present equipment.

Terminal Equipment

The varied types of service which may be required, particularly the interconnection of a multiplicity of drops with carrier terminal legs on a half-duplex basis at a multipoint hubbing center, and the desirability of utilizing standardized equipment throughout, led to the adoption of d-c transmission on patrons' loops rather than the use of extended carrier legs. This d-c loop equipment has been engineered to accommodate a transmission speed of 1000 bauds over balanced pairs with a steady-state loop current of three to five milliamperes. Only simple resistance-capacitance equalization networks are required at this speed.

An important consideration in data handling by a common carrier involves the actual interconnection of the data processing equipment at the patron's location with the common carrier's equipment also at the patron's location. It is quite obvious that standards must be set if confusion is to be avoided. To this end Standards Proposal No. 576 has been prepared by the Electronic Industries Association for the Interconnection of Data Terminal Equipment with a Data Communications Channel. The Telegraph Company follows these proposed standards for the particular type of service furnished to the patron. In addition, facilities for the alternate use of the data circuit for teleprinter communication and means for checking the common carrier transmission equipment at the patron's office are also provided.

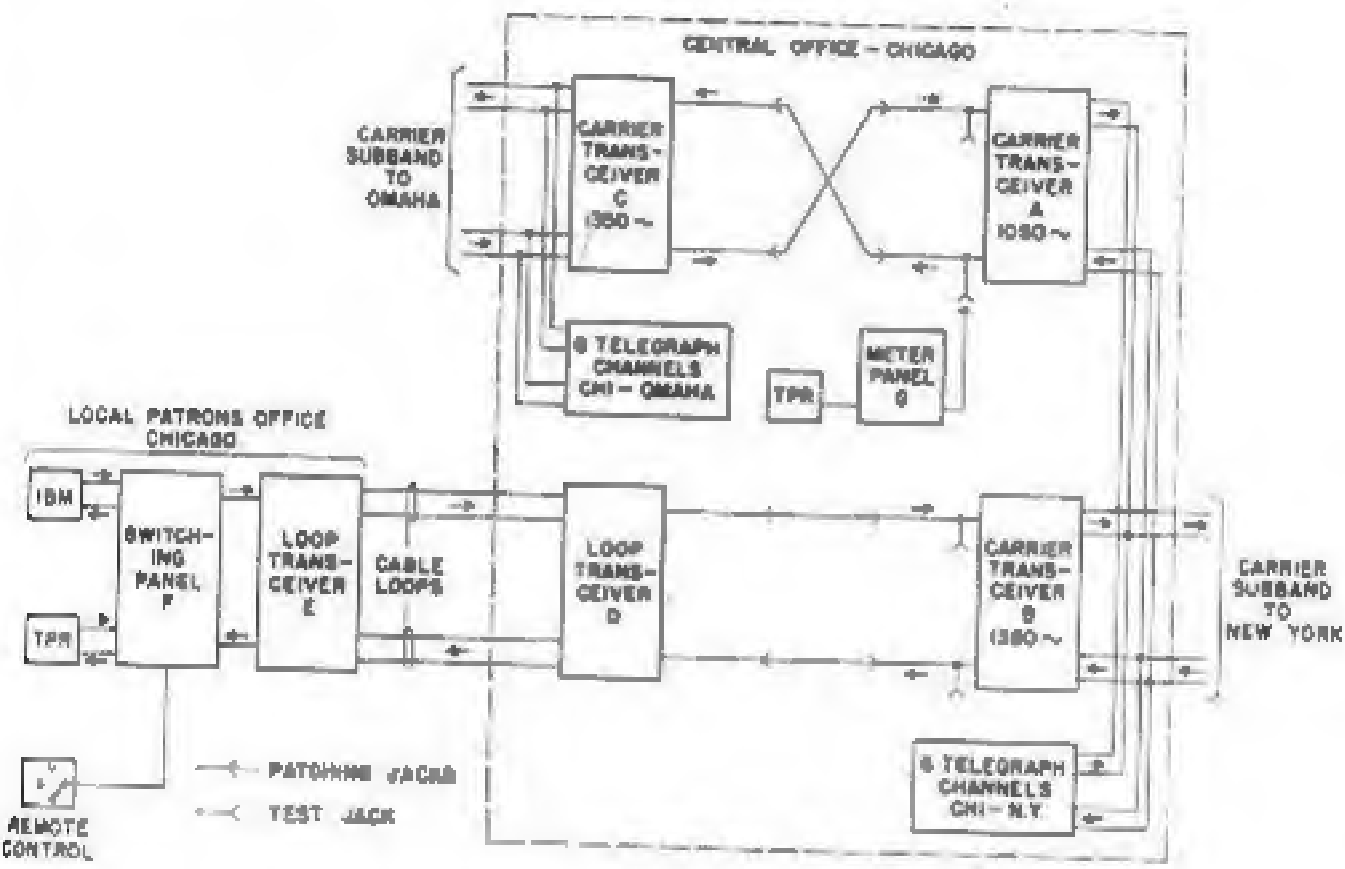


Figure 1. Point-to-point service, typical installation

Data Systems

Figure 1 illustrates one version of a point-to-point system furnishing one 180-baud data channel with New York and Chicago terminals and one 180-baud channel via Chicago with New York and Omaha terminals. Two data channels A and B centered at 1050 and 1350 cps respectively, and six regular telegraph channels at 375, 525, 675, 825, 1575 and 1725

cps occupy one subband between New York and Chicago. The legs of carrier transceiver A are patched to the legs of transceiver C to establish the New York-Omaha connection. The Chicago-Omaha subband also carries eight telegraph channels, one channel at 975 and one at 1125 replacing a 1050-cps data channel not used in this section.

The legs of carrier transceiver B are patched to the legs of loop transceiver D. This transceiver converts the grounded polar signals of the carrier transceiver leg to a form suitable for transmission to the patron's premises over a balanced pair. Loop transceiver E on the patron's premises converts the receiver loop signals back to grounded polar form.

At the patron's office the data circuit is used to operate an 11-card-per-minute IBM transceiver. For this particular application switching panel F is required to match the 10-milliampere legs of the loop transceiver to the higher impedance legs of the IBM set. The switching panel also permits use of the data channel for printer communication and provides means for testing the operation of the loop transceiver. Data, printer or test functions may be selected by remote control from an operations center.

At the Telegraph Company central office meter panel G and associated printer form a common piece of test gear which may be corded into any data circuit. It permits printer communication either over the carrier link or over the patron's loop and also provides for metering of signals in the transceiver legs without interrupting the circuit.

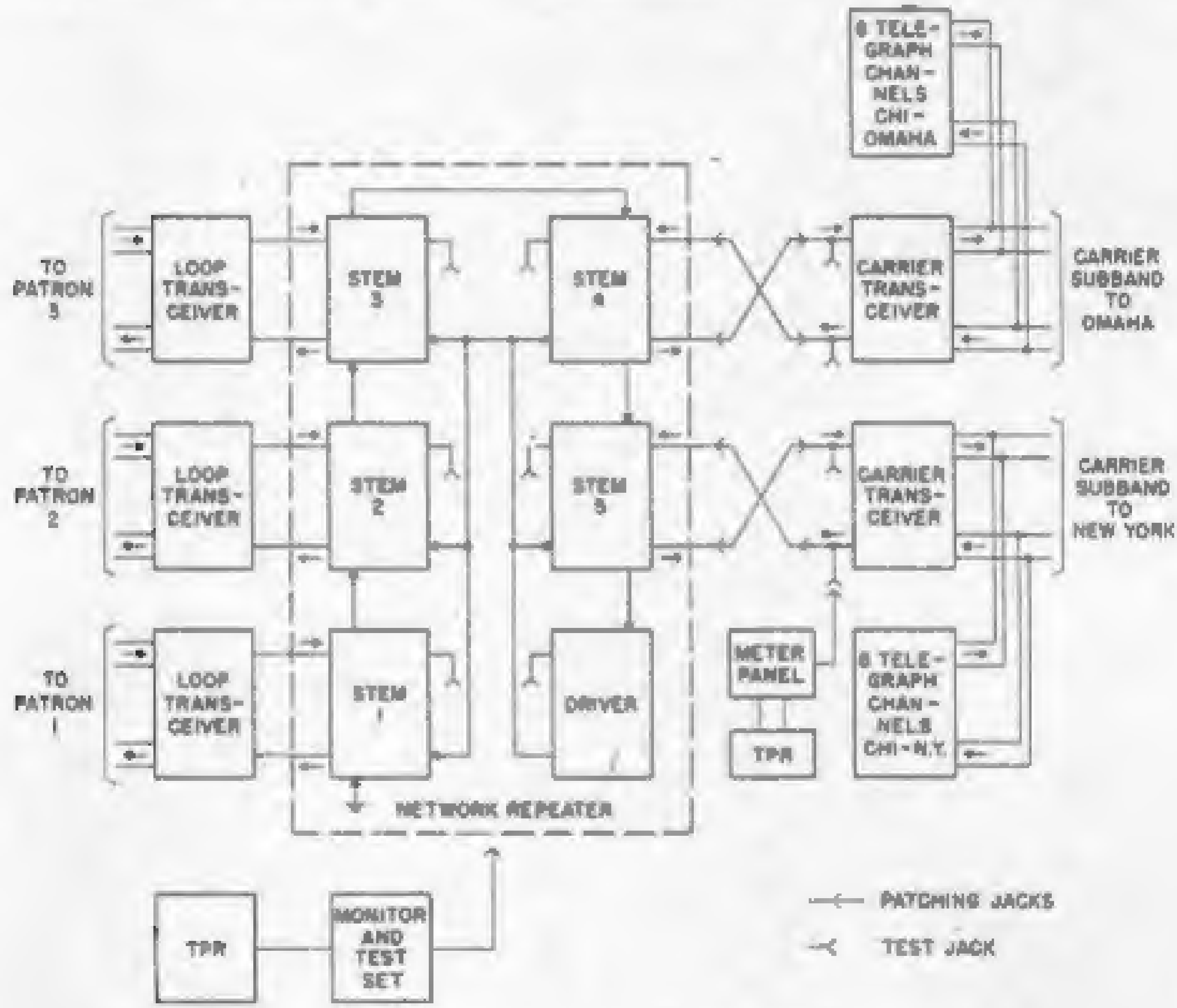


Figure 2. Multipoint service, typical installation

Figure 2 illustrates equipment arrangement at Chicago on a multipoint system which includes New York, Chicago and Omaha. It is to be understood that similar equipment appears at New York and Omaha and also that the system is not

limited to three hubbing points. Three are shown here only for convenience.

Chicago patrons are connected into the network through the network repeater. Functions of other equipment shown are the same as was outlined in the point-to-point system of Figure 1. With the arrangement shown operation is half duplex whereby any one station communicates with all others in the network. A program type operation is in development in which each station uses the circuit only on invitation to query a central computer and receive a reply.

The factor limiting transmission speed in either system is the 180-baud carrier channel. By using a full subband with delay correction and regenerative repeaters where necessary, operation at 1000 bauds is possible throughout the entire network.

DATA TRANSMISSION EQUIPMENT

All of the circuit equipments indicated on Figures 1 and 2 have been developed and are now in limited production. The carrier transceiver for 1000-baud operation has also been developed and prototypes tested on actual circuits. It should be of interest to cover briefly the theory of the most important items.

180-Baud Data Carrier Transceiver

This component, shown in Figure 3, is a directly modulated frequency-shift transceiver operable on a carrier frequency of 1050 or 1350 cps. The unit is completely transistorized and conventional frequency-shift techniques are used throughout. Marking frequency is 80 cps below and spacing frequency 80 cps above channel mid-frequency to produce a 160-cycle shift. The impedance of the sending leg is 620 ohms to ground and the impedance of the receiving leg 620 ohms to 12.5-volt polar battery.

The band-pass channel filters are conventional in design except that some departure from usual practice is introduced in the sending filter to reduce delay distortion. Adequate suppression of higher order sidebands of the wide-band frequency-shift keying requires this filter to have a pass band narrower than that required in the receiving filter. Insertion loss and envelope delay characteristics of the sending filter of the 1350-cps channel

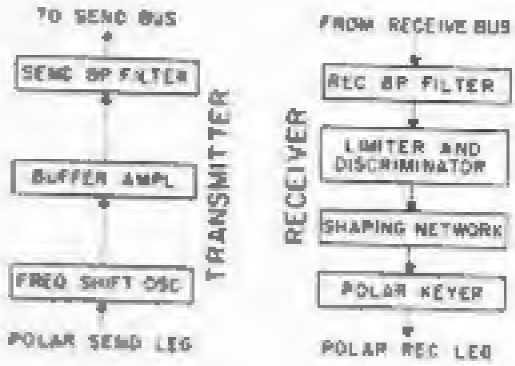


Figure 3. 180-Baud carrier transceiver

are shown on Figure 4. Both sending and receiving filters are designed to parallel with the standard 600-ohm telegraph channel filters.

Following the receiving filter, a two-stage push-pull limiter provides 35 db of limiting and the required power output for driving the discriminator. Two series-tuned circuits are used in the discriminator, one tuned below the marking frequency and the other above the spacing frequency. The currents from the two circuits are individually rectified and differentially added to produce a polar signal output current. The signal-shaping network discriminates against frequencies above 90 cps and shapes the signal for minimum distortion. Polar current from

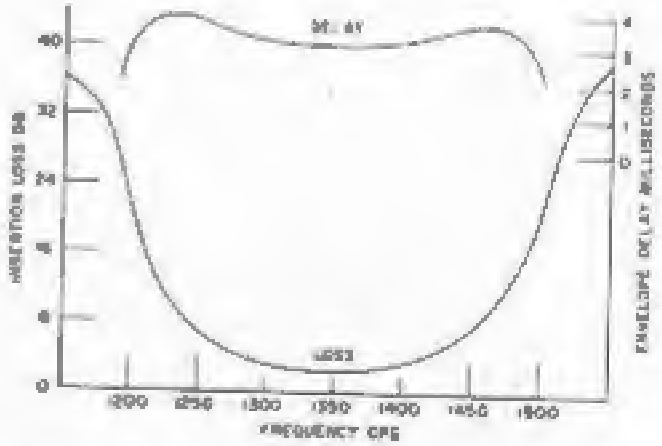


Figure 4. 180-Baud data transceiver, sending filter, 1350-cps channel

the filter drives a two-stage directly coupled complementary transistor output circuit which functions as a post-detection limiter and polar output keyer. The polar output voltage is 12.5 volts through 620 ohms. Thus when the receiving leg of one channel is patched to the sending leg of another channel a current of 10 ma will flow. The unit contains rectifier supplies to provide minus 25 volts and plus and minus 12.5 volts from 115 volts ac. When operating over a normal voiceband, maximum distortion introduced by the equipment is 5-percent characteristic and 2-percent fortuitous.

1000-Baud Data Carrier Transceiver

The transceiver shown in Figure 5 has been developed to utilize a full subband for speeds up to 1000 bauds. Again frequency-shift operation is used with a center frequency of 1000 cycles and a deviation of 400 cycles, the spacing and marking frequencies being 600 and 1400 cycles respectively. To transmit at such a high modulation-frequency to carrier-frequency ratio over a medium which does not rigidly preserve this ratio precludes

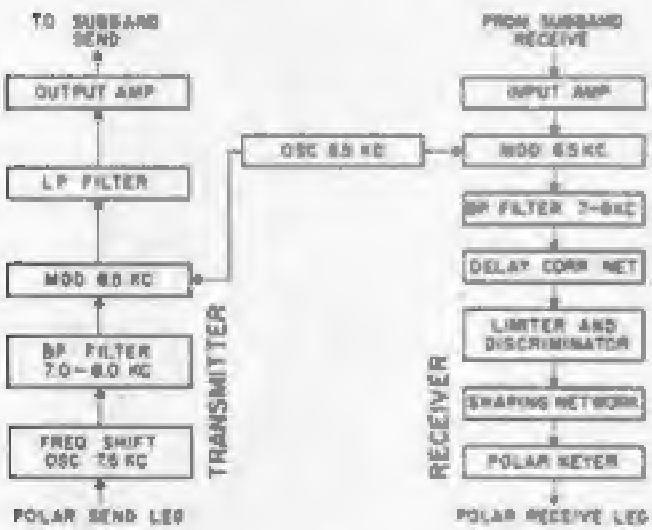


Figure 5. 1000-Baud data carrier transceiver

the use of direct modulation. Also demodulation of a frequency-shift signal uses only the crossover information of the received carrier signal and so provides insufficient samples completely to define the modulation envelope.

These difficulties are avoided by using a double modulation method. The frequency-shift signal is generated at 7.5 kc and with a deviation of ±400 cycles and passed through a band-pass filter to restrict the sideband energy to a 1400-cycle band. The carrier signal is then modulated with an 8.5-kc carrier and the lower side-

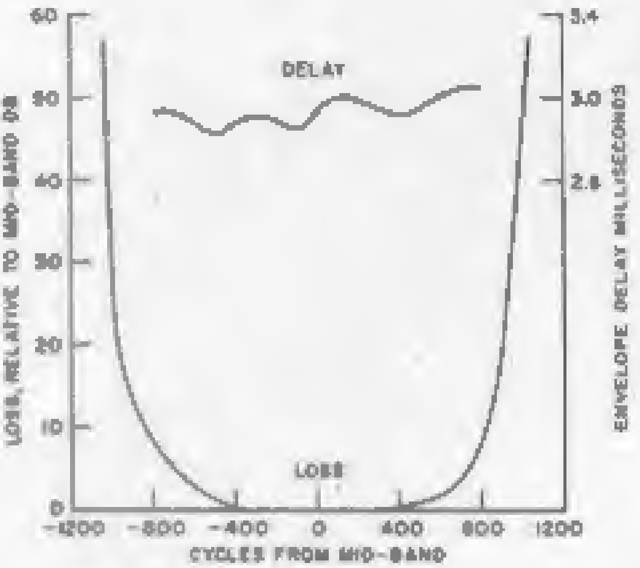


Figure 6. 1000-Baud data transceiver, transmission characteristics

band selected for transmission over the subband. The 7.5-kc carrier adequately defines the modulation envelope and this information is retained when the 7.5-kc carrier signal is translated to 1 kc for transmission. To retain this information at the 1-kc level, nonlinear circuits such as limiters must be avoided until the signal is retranslated to the 7.5-kc level. This is accomplished at the receiver by another 8.5-kc modulator and a band-pass filter which selects the lower sideband in the 6.8- to 8.2-kc range so that the signal is restored to its original high-frequency state. At this point a delay correction network compensates for the delay distortion introduced by the sending and receiving circuits of the transceiver. The transmission characteristics with the corrective network added are shown on Figure 6. The signal is then limited and demodulated in the conventional manner and delivered to the receiving leg. Again both sending and receiving legs operate with 10-ma polar signals.

On a back-to-back basis the maximum characteristic distortion at speeds up to

1000 bauds is two to three percent. In normal operation external networks correct the delay distortion introduced by the subband modulating equipment and carrier system voicebands to limit the characteristic distortion to about twice the back-to-back value.

Data Loop Transceiver

For reasons previously mentioned, transmission between the central telegraph office and the patron is on a d-c or video basis and separate sending and receiving loops are employed. Transmission is accomplished by data loop transceivers located at both the central office and the patron's premises.

A block diagram of the loop transceiver is shown on Figure 7. The transmitter phase splitter converts the 10-ma ground return polar signal from the sending leg to a push-pull form. This signal operates an electronic switch to apply ground to one side of the loop and a negative voltage to the opposite side for a marking signal, or to reverse these conditions for a spacing signal. Since the distant end of the loop is terminated free of ground and the impedances to ground and to battery at the sending end are equal, effective suppression of extraneous interference is obtained. For this reason steady-state loop currents of 5 ma or less permit distortion-free operation at 1000 bauds over cables having loop resistances of 5000 ohms or more.

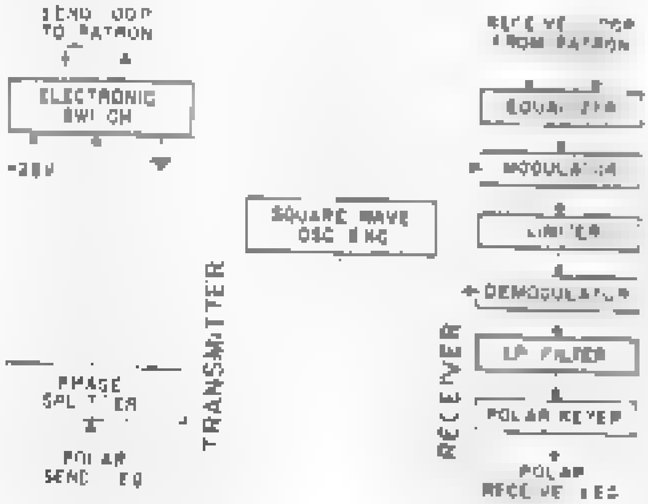


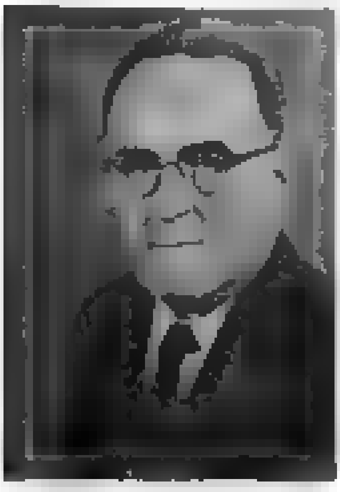
Figure 7 Data loop transceiver

The receiving portion of the transceiver accepts signals from the loop and applies them to a balanced half-section LC filter to reject components above 500 cycles. The signals are then equalized for amplitude and phase in a simple balanced RC equalizer. The equalizer is adjusted for equal output at 25-cycle and 500-cycle dotting signals. A double balanced modulator driven by a 6-kc square wave carrier converts the d-c push-pull signal from the equalizer to a 180-degree phase-modulated carrier signal. One phase represents a marking signal and the opposite phase a spacing signal. Bias control is effected by adjusting the sense and magnitude of the carrier unbalance of the modulator. The unbalance in phase with the marking or spacing carrier signal respectively introduces marking or spacing bias. The output transformer of the modulator provides d-c isolation of the loop circuit. The phase-modulated carrier signal is raised to a high and constant level by a limiter and then demodulated by the same 6-kc square wave carrier to recover the d-c polar signal. Since both modulator and demodulator are operated from the same carrier source, the oscillator does not have to meet rigid stability requirements.

The demodulator output is filtered to remove carrier transients and drives a series complementary output limiter circuit to deliver 10-ma polar signals to the receiving leg.

NETWORK REPEATER

The transistorized network repeater is shown in Figure 8 and differs somewhat from its relay equivalent currently in use for telegraph networks. Each patron's local sending loop is terminated in a PNP transistor switch. All these switches are series-connected between ground and a d-c driver amplifier. When all the patrons' sending loops are on marking (negative battery) all the transistor switches are closed and positive signal is applied by a resistor divider network to the driver amplifier. Under this condition the driver amplifier applies a negative signal to all the polar keyers causing them to transmit



Albert Boggs, Assistant to the Transmission Engineer, majored in physics at Ohio State University graduating in 1925. Following a year there as Graduate Assistant in Physics, he received the Master of Science degree and then joined the Research Division of Western Union. His activities have included mathematical studies of various phases of signal transmission, investigation of inductive interference and development and application of mitigative equipment, development and application of carrier loading and impedance matching systems, correction of distortion and related problems. Mr. Boggs heads the group which is responsible for development of inductors, transformers and electric networks, and which has designed the numerous types of filters widely utilized in Western Union carrier systems. He is a member of Phi Beta Kappa, and Pi Mu Epsilon, honorary mathematics fraternity.

A biographical sketch of **Mr. Boughtwood** appears in the April 1958 issue of TECHNICAL REVIEW.

a marking signal to their individual patrons' receiving loops.

A spacing signal (positive battery) from any patron's sending loop causes the associated transistor switch to open. This breaks the ground connection and the divider network applies a negative potential to the driver amplifier. As a result the driver output goes positive, causing a spacing signal to be transmitted to the individual patrons. In half-duplex service it is necessary to prevent transmission back to the patron who is sending. This is done by inhibit circuits connected between the sending and receiving side of each network stem. When a patron sends a positive spacing pulse into the network repeater the associated inhibit circuit clamps the polar keyer in the marking condition by overriding the signal from the d-c driver amplifier. The polar keyers for the other patrons are not affected due to the isolating resistors between the driver amplifier and each keyer.

Both sending and receiving legs operate on a 10-milliampere polar basis. As many as 20 circuits may be hubbed with no difficulty. Due to the transistor circuitry and because only local transmission circuits are involved, operating speeds are in no way limited by the network repeater.

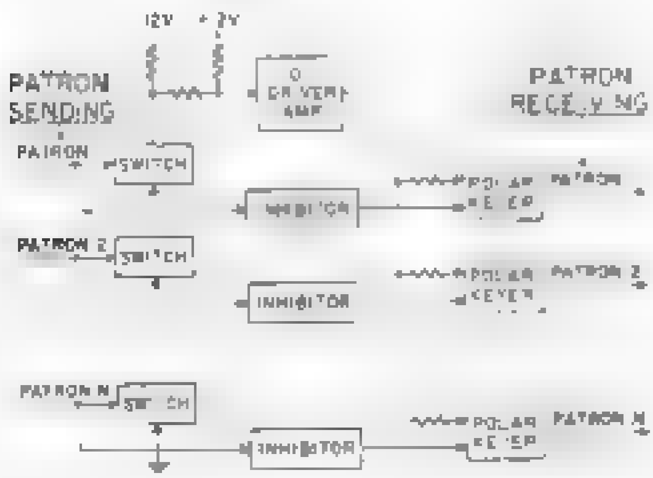


Figure 3. Network repeater

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Although experience with these higher speed data circuits has been limited, the indications are that they will be fully as reliable as the older low-speed circuits. In tests on average length circuits operating in IBM service at 150 bauds with full 80-column cards and with error detection, cards were rejected at an average rate of one out of 3300 for errors.

Experience with the 1000-baud carrier

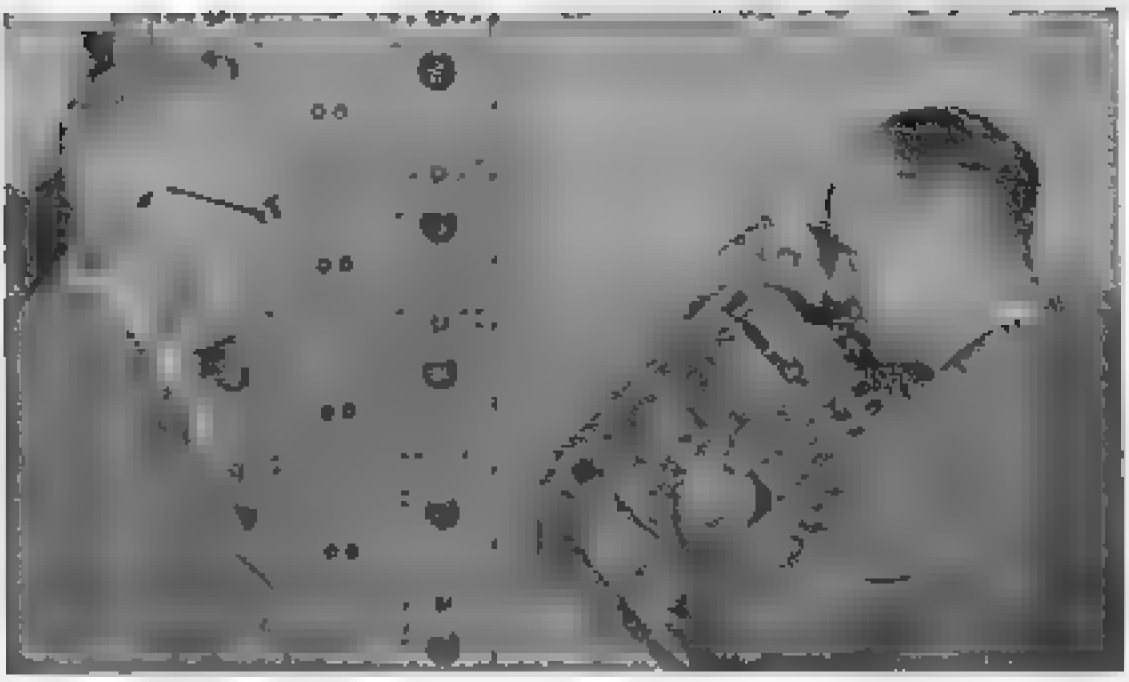
data terminal has been limited to laboratory back-to-back tests over typical sub-band circuits at a 600-baud speed. Indications are that error rates in the neighborhood of one character in 300,000 may be expected on normal circuits.

Field experience has been limited to point-to-point service but all necessary transmission equipments for multipoint network service have been developed and are currently available. Multipoint system circuit layouts to meet the specific requirements of several potential users of this equipment are already in the advanced planning stage and initial installations for field trials will soon be made.

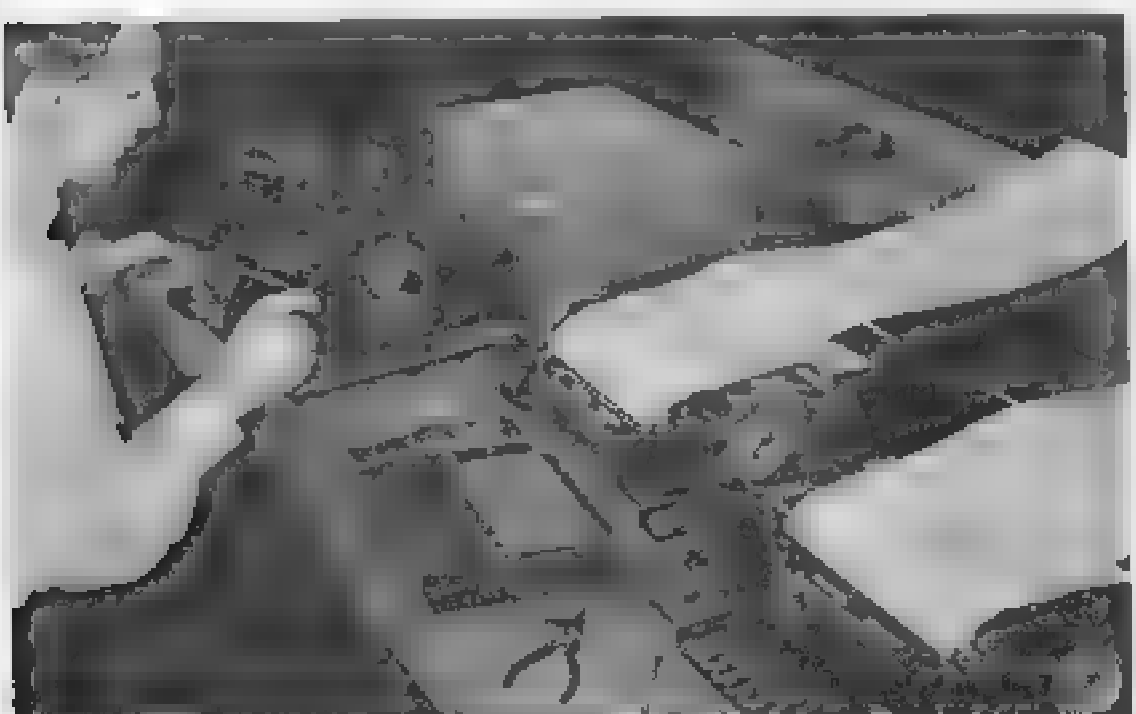
With this ground work completed it is believed that the foundations have been laid for a comprehensive data handling system readily adaptable to a variety of high-speed services. This system can be realized with a minimum reorganization of present operating practices and with a maximum utilization of existing facilities.

OVER 35,000 WESTERN UNION DESK-FAX IN TEN YEARS

During peak activity of the 1949-1959 Desk-Fax program 600 new customer installations were added monthly.



Audio Frequency Amplifier AM-911 FG designed and produced by Western Union is examined at company's Water Mill (N.Y.) Electronics Research Laboratories by L. G. Pollard (left) and C. R. Deibert. Amplifier is component of widely used carrier telegraph system AN FGC 29.



Prototype of new miniaturized page teleprinter which is being specially engineered by Teleprinter Corporation to meet Western Union requirements is tested in the Telegraph Company's equipment laboratories. Smallest and lightest teleprinter yet developed, it can be adapted for military purposes.

HARRY C. LIKEL, Senior Project Engineer, Transmission

The Maser, A Low-Noise Microwave Amplifier

Signal-to-noise ratio at a receiver output determines the usefulness of the signal. At ordinary radio frequencies, man-made and natural static noise levels are so high that receiver noise is usually unimportant. At microwave frequencies, however, static-type noise is almost entirely absent so that noise generated in the receiver has until recently been a limiting factor. Now, with the advent of the Maser and the parametric amplifier, a great reduction in receiver noise has been made and a new limiting factor appears—the thermal noise in the area from which the receiving antenna, which is usually very directive, accepts signals. An antenna directed at a distant horizon and "seeing" a large segment of the earth's relatively warm surface will pick up more thermal noise than one directed toward the sky and the cold reaches of interstellar space.

M-A-S-E-R stands for "Microwave Amplification by Stimulated Emission of Radiation," which is a short description of the Maser's function.

Some Masers are important to radio reception because in the microwave region where the Maser operates there is relatively little natural or man-made static. Thus the limitation upon how weak a signal may be and remain useful has been the noise generated within the receiver itself. The Maser amplifier adds very little noise to that which is picked up with the signal and, therefore, makes it possible to amplify and use weaker, and in some circumstances, such as found in radio astronomy, much weaker signals than previously possible. The parametric amplifier, although not as noise-free as the Maser, is about as good as there is any need for it to be when the antenna is directed along the surface of the earth.

Two Types

To date two main types of Masers have been developed. Those of the first type depend for their action on changes in the internal energy state in whole molecules, while those of the second depend on changes in the energy state of individual electrons.

The molecular Masers are not of much use in radio reception because they operate at sharply defined frequencies which are determined by the energy differences between the possible internal states of the particular molecule. At present there is no good way of influencing or affecting these states. The frequency generated by the ammonia or other molecule in a Maser oscillator seems less subject to change than anything else science has yet measured. The speed of light, for example, varies with the medium in which it travels; stars do not maintain the schedule of their courses with anything like the accuracy with which these molecules maintain their "frequency."

The class of Maser in which the electron, rather than the molecule, is the active element, however, not only acts over a band of frequencies but is tunable. To understand why this is so, let us see how this class of Maser works.

In the first place it must be accepted that every electron has the properties of a small magnet. In nonmagnetic substances, all the electrons form magnetic couples with a neighboring electron in the atom; that is, north of one to south of another, just as magnets usually will do if allowed to orient themselves when brought close together. In the case of electrons the fields may be indivisible, i.e., unit fields and, therefore, electrons in this coupled state produce no field outside the atom and no response by the material to a field passing through it, since no field powerful enough to open these intra-atom couples is yet known.

In paramagnetic substances, that is, those having a permeability greater than 1, some of the electrons are not in magnetic couples within the atom to which they belong. The lines of force from these electrons form relatively long loops through the material, loops that are easily broken when an external magnetic field passes through the material. These "unpaired" electrons then line up magnetically with this field in greater and greater numbers as the field becomes stronger.

Energy Transfer

Now an almost unbelievable phenomenon can take place. If just the right amount of

energy is delivered to one of these electrons it will be turned around and left "stuck on dead center," so to speak, with its field opposing the external field. When in this condition it has potential energy which it gives up when it snaps back to its normal position. Thus we see it can have two energy states.

If the material in which the magnetically unpaired electrons exist is a nonconductor such that a radio wave can penetrate it, then energy necessary to put electrons in the higher energy state may be extracted from the wave if it is of the correct frequency and of great enough intensity.

What the frequency must be depends upon the material and upon the strength of the applied magnetic field. In materials where there is more than one unpaired electron per atom, it takes one amount of energy to "set up" or raise the first electron to the higher energy state, a different amount to set up the second, and the sum of these two to set them up in pairs. The greater the energy required, the higher the frequency a radio wave must have to set up the electrons. This wave is called the pumping wave and its frequency the pump frequency. Therefore, with a pumping wave of the correct frequency, it is possible to set up the electrons two at a time. If the Maser material is at room temperature, the violent banging about of the molecules, which is the phenomenon of heat, will quickly dislodge the electrons from the high energy state to which the pumping wave has raised them. As they fall back, they will give up the energy extracted from the pumping wave in the form of radio waves at two lower frequencies representative of the energy change by each individual electron.

At room temperatures this is a process upon which a weak wave at one of the lower frequencies would have but little effect. If, however, the material of the Maser is cooled with, say, liquid helium to a temperature of 4 degrees Kelvin (—269 degrees C or —452 degrees F, which is 4 degrees C above absolute zero where all molecular motion stops), the molecules are relatively still and the pump may easily place many atoms in the highest energy state, that is, with two electrons reversed. Even at this low temperature atoms will fall from this state to the next lower state due to thermal effects, and from it to the nonenergized state as first one then the second electron turns back. They are induced to make one of the energy changes more easily, so the other of the two downward transitions becomes the "bottleneck" in the process. The frequency of the wave given off by the first of these releases of energy is called the idler frequency, the second the Maser frequency.

Amplifier Action

If, now, a weak wave of the frequency given off by electrons making the bottleneck or Maser frequency transition is applied to the Maser material in addition to the pumping wave, it will dislodge quantities of these electrons and in proportion to its own strength. The dislodged electrons then give up their energy to the weak wave and not only at its frequency but in such phase as to reinforce it. Thus the lower frequency wave, that is, the signal, extracts energy from the Maser as it passes through and comes out amplified while the Maser will increase the energy it extracts from the pumping wave by the amount needed to make this possible.

Because the Maser material is not perfectly homogeneous nor the applied magnetic field perfectly uniform, not all the electrons respond to exactly the same frequency. For this reason, this class of Maser responds over a band of frequencies and can be used to amplify modulated waves.

Practical Maser amplifiers so far built employ crystals of nonconducting materials containing paramagnetic atoms in their lattices, such as synthetic ruby. The crystal is suitably located in a waveguide structure with provision to supply the necessary magnetic field and cooling. It is subjected to the effects of pump frequency and signal frequency waves passed through the guide. If everything is right, the desired low noise amplification of the signal wave results.

Because of the need to cool the material to extreme low temperature, if for no other reason, it is unlikely that Maser-equipped receivers will be used in ordinary commercial applications such as found in radio beam systems. However, in very specialized applications, such as radio astronomy, beyond-the-horizon reception, long-range radar and missile detection and tracking, it is extremely valuable.

A biographical sketch of the author appears in the October 1957 issue of Technical Review.

L. A. SMITH, General Supervisor, Industrial Engineering

Production Scheduling at the Chattanooga Works

After equipment manufacturing on an effective but modest scale succeeded pole treating, camp car maintenance and fabrication of wooden operating and apparatus tables at the Western Union plant in Chattanooga, Tenn., a control system well suited to variations in production requirements was introduced. Inventory and payroll records were mechanized.

NUMEROUS changes have taken place in the plant layout and the operational functions of the Chattanooga Works since the last description of that Western Union plant appeared in TECHNICAL REVIEW.[1] Permanent schools have been established for instruction in equipment maintenance and wire-and-repeater techniques. Many clerical functions have become mechanized processes. Outmoded labor operations such as those involved in camp car maintenance, pole treating and woodworking have been abolished. Over-all, the plant is now engaged in a much wider scope of manufacturing processes and is performing them in a modern and efficient manner.

Plant Facilities

The metal shop is a modern, well-equipped fabrication plant capable of performing widely diversified types of work such as making complicated metal frameworks, cabinets, consoles, and so forth. The frontispiece shows a power brake which is capable of bending one-quarter inch mild steel to a 90-degree angle. Punch presses of different sizes are available ranging from foot punches to large power

punches. One of the latter, a 100-ton press can handle the biggest job yet encountered, or anticipated, in the manufacture of telegraphic units. Another, the Wales Fabricator, is a versatile power punch equipped with a pantograph arrangement which permits the rapid duplication of a complicated pattern of different-sized holes. This arrangement eliminates laying out hole locations on individual sheets of stock, or setting up separate jigs for the position of each hole, or laboriously preparing a complicated gang-punch arrangement. Drill presses, a power saw, a modern high-speed abrasive cutoff machine, and other machinery associated with efficient metal fabricating practices are part of the equipment. Facilities are also provided for spot, gas, and arc welding

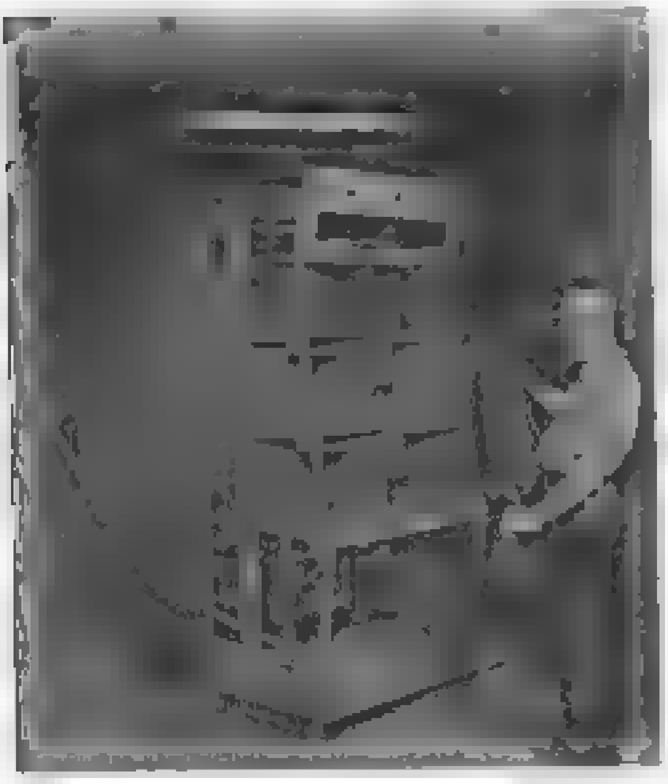


Figure 1 Spraying booth

The paint shop is equipped with three spraying booths. Figure 1 depicts a typical cabinet framework being sprayed in one of the booths. Prior to painting, all equipment is degreased by dipping the unit in a large hot vapor vat which removes greases and oils that unavoidably adhere to the metal during fabrication. The unit is then sanded, if necessary, and given a primer coat. A final coat, usually the standard Western Union wrinkle-type finish, is

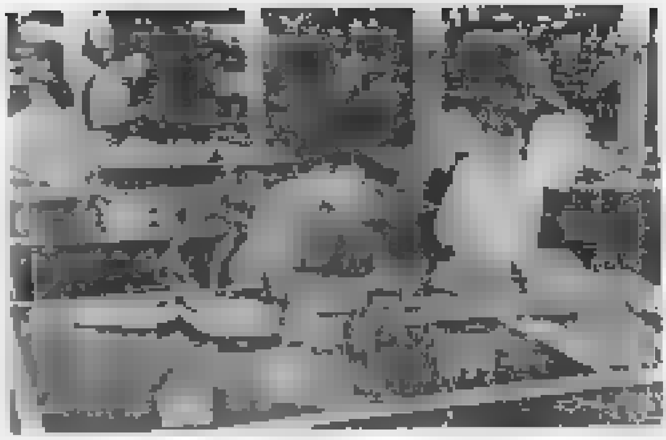


Figure 2. Making cable forms

applied. Both coat applications are dried individually in electrically heated ovens There are two ovens, each of which is 8 feet wide, 10 feet deep, and 8 feet high

The assembly and wiring section of the shop was discussed at length in Mr Trent's article and, therefore, will not be described now Two general views of this section appear in Figure 2 (cable forming) and Figure 3 (assembly and wiring of large cabinets)

In the packing and shipping section heavy wooden packing cases have been replaced by modern wire-bound crates The reduction in the gross shipping weight of one product, from 301 to 208 pounds is a typical illustration of the advantage resulting from this change

Control Features

Any one finished product from the Chattanooga Works, such as switching rack, console, switchboard, and so forth, undergoes many work phases to convert it from the original raw steel, wire and other materials from which it was fabricated. Adequate control of these various operations is essential to good management as well as to expediting equipment for our patrons' use. To facilitate management control of the accomplishment of both goals, new work systems were developed and installed at the Chattanooga Works.

The first step in the program was the mechanization of payroll procedures (in 1957) to provide accurate information quickly for cost accounting, production control and other purposes. The mecha-

Figure 3. Assembly and wiring of cabinets

nized procedures follow a typical "out-station payroll" plan.[3] The source data taken from plant timecards are add-punched and transmitted to the Integrated Data Processing (IDP) Center in Atlanta.

There they are mechanically and electronically processed to produce, in addition to pay checks, fundamental data for many phases of management control. Exact information for each type of work required to produce a given unit is also developed. For example, the man-hours used for shearing, drilling, tapping, and so forth, on a given job are individually determined and reported.

Although the layman may consider the Chattanooga Works to be limited to "job shop" type of operation, the work actually covers the gamut of telegraphic unit manufacturing. This ranges from a single small support bar that can be made in a few minutes to the assembly line production of large complicated cabinets. In order to provide efficient control of the movement of all shop orders as they progress through the plant, a new scheduling system was installed in 1958.

Work Scheduling

This new system used at the Chattanooga Works is a modification of a standard control system employed by many manufacturers. The standard system, as originally developed, is capable of rigidly controlling the individual manufacturing operations and the movements of products through a plant. However, the high incidence of job-lot orders and nonrepetitive types of work at the Chattanooga Works made strict adherence to the standard system impractical. A modified system which can readily be converted to the rigid detail control standard system whenever desired was, therefore, adopted. This modified system provides for the analysis of work loads during the different periods of the work progress time scale, as indicated below:

1. Future Periods (more than 2 weeks away): Orders received are "rough scheduled" for future processing.
2. Immediate Future (limited to 2 weeks): Actual production for "this week" and "next week" are "fine scheduled."
3. Present Time (daily postings): Daily work progress is indicated by signalling devices.

To provide for contingencies and emergency rush orders, only 90 percent of the plant man-hour capacity is rough scheduled, the remaining 10 percent is left unallocated until work reaches the fine-scheduling stage.

When a job is first received, it is analyzed for rough scheduling and a Master Production Control Card (Figure 4) is prepared. Details for the future manufacture of the item are recorded on this card for each major section or "cost center" in the shop. The cost centers represent the major breakdowns which are necessary for production cost records, as follows:

Cost Center 11 — Layout section of the metal shop

Cost Center 10 — Metal-fabricating section

Cost Center 20 — Painting section

Cost Center 33 — Wire-forming section

Cost Center 30 — Assembly, wiring and testing section

Cost Center 40 — Packing and shipping section

In preparing the master card, the total man-hours required in each cost center are estimated on the basis of past experience and historical records and spread over an appropriate number of weeks to obtain the manufacturing lead time. Calculating backward from the desired com-

Figure 4. Master production control card

Figure 6A. Shop production control card

pletion date, the required starting date for each cost center is determined and scheduled.

Data from the individual master card are then posted to a "forward load folder" (Figure 5), one of which is maintained for each cost center for each future week

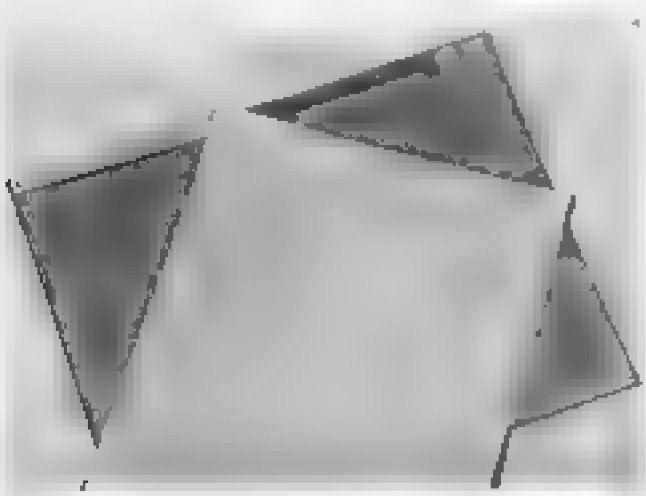


Figure 5. Rough scheduled accumulative man-hours

Movable visual scale markers provide immediate information as to

1. Total man-hours actually rough loaded to date
2. The 90-percent limit which may be rough scheduled

Reading of the visual signal markers will disclose when manufacturing time in any given cost center will be available for additional jobs. The rough-scheduling procedure places the Chattanooga Works in an excellent position to predict when each project will be completed and shipped. It also permits advance planning of force requirements to meet long-range variations in the work load. Short-term variations can be adjusted for by shifting a few of the scheduled jobs.

The important consideration from the viewpoint of the installation forces is "How much will be delivered, when?" The man-hours required and the production starting date of an order are of little value for installation planning purposes. Therefore, a completion date summary is prepared from the rough-scheduled data for such use and the promised completion dates will be met with a high degree of dependability owing to the scheduling system.

Card Records

When the actual production time approaches, i.e., two weeks prior to the start of the job, the applicable forward

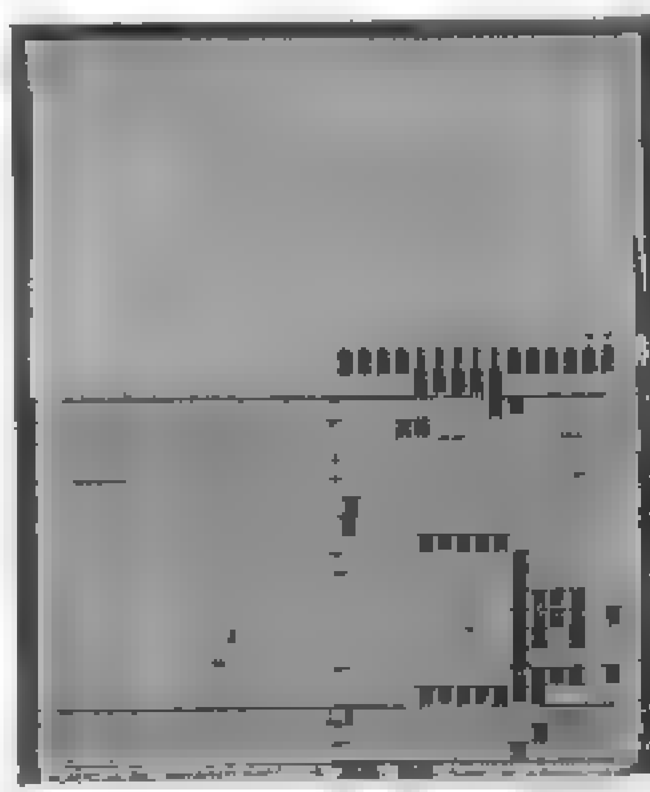


Figure 6B. File of shop production control cards showing job location indicators

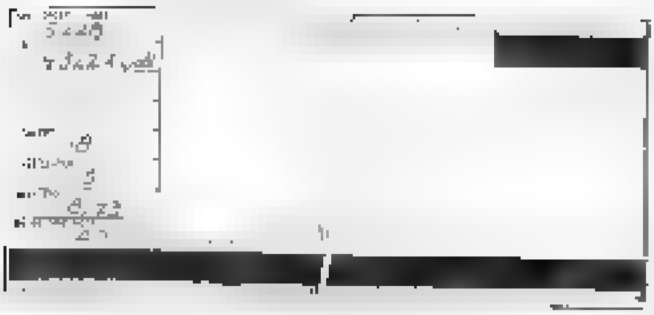


Figure 7A. Sched-U-Graph card

load file is removed and all jobs rough scheduled are fine scheduled. The total estimated hours required each week are balanced against the estimated available hours adjusted for absenteeism, vacations or holidays. Last-minute rush jobs and/or other fill-in projects are added to the schedule at this time in order fully to utilize all available man-hours.

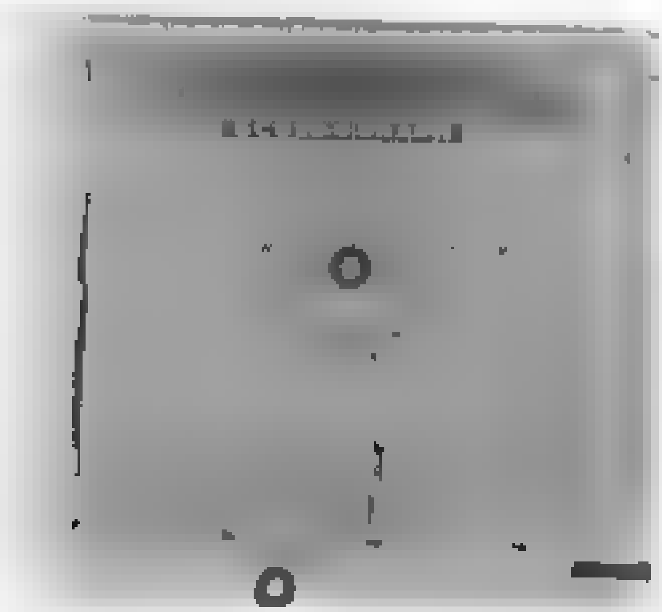


Figure 7B. Sched-U-Graph board with work progress indicators

To fine schedule, an individual shop production card (Figure 6A) and a Sched-U-Graph card (Figure 7A) are prepared for each job in the fine-scheduled group. The shop cards, marked to show every operation involved, are then arranged in a visible file (Figure 6B). Movable spot-tabs are attached to show the work area currently affected by each card. A foreman can tell at a glance how many and which orders are located at each machine or work station. The visible file, together with the daily progress signalling system described later, permits the foreman to assign his force most effectively to meet the schedule.

The Sched-U-Graph card, variously colored to identify the urgency of the job, has a scale divided to represent 40 normal working hours in a week. If 32 hours are required for a job, the portion of the scale beyond 32 is cut off. When the total hours required is 40 or more, a full-length card is used. These cards are made up into a Sched-U-Graph board where sliding markers are employed to indicate the work progress (Figure 7B). The interpretation of the scale divisions in moving the markers is explained in a subsequent paragraph.

The actual labor hours from timecards are transmitted to the Atlanta IDP Center for payroll purposes. After summarization a daily report of the data is sent to Chattanooga and the information is posted to the Sched-U-Graph board by shifting the movable signals. A time lag due to the IDP processing is inevitable, and in actual practice the IDP results are available for posting at the start of the second working day after the work has been applied to the job. In shifting the markers the scale divisions on the various cards are translated in the following manner:

Total hours required for job	Value of each scale division
32	1 hour
40	1 hour
240	6 hours

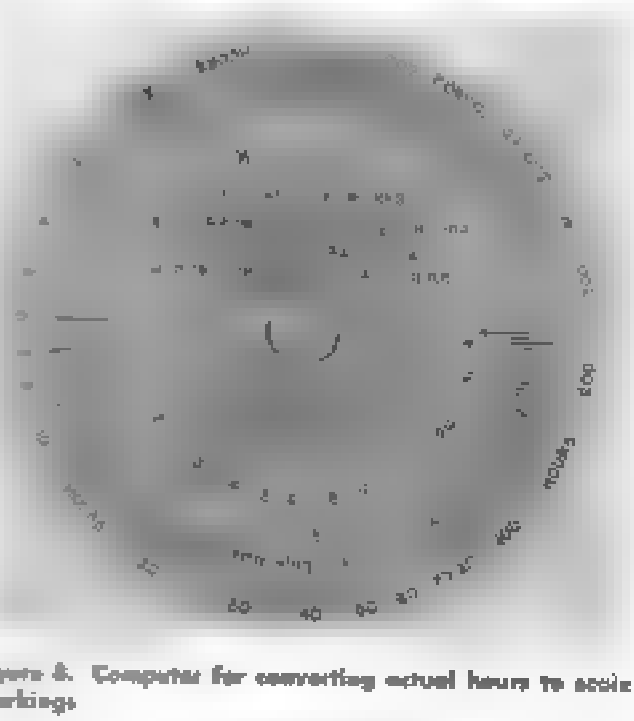


Figure 8. Computer for converting actual hours to scale markings

In the case of a job requring 240 hours, and where 85 hours were applied, this would be equal to 14/40ths on the scale and the marker would be moved to 14. To provide a rapid and accurate conversion from actual hours to scale markings, a special circular slide rule computer was devised. Figure 8 illustrates the setting which would yield the scale data for the example above. In actual use, this device has proven to be very valuable and easy to use. For jobs requiring 40 hours or less, this procedure is not necessary since the scale can be read directly

Control Reports

Another report as to weekly status is prepared by the IDP Center from the orginal timecard data. It provides accumulative data on each shop order and includes the date completion was promised, the number of units completed to date, and the percent of estimated time used to date. A monthly management control report (MCR) permits a rapid evaluation of shop performance on all shop orders completed through any section of the shop during the month. The MCR also indicates the scheduled and the actual completion dates relative to each shop order

Further facilitation of production and cost control has been accomplished by mechanizing the maintenance of material control records. All source documents relative to material handling, i.e., requisitions, packing slips, disbursement tickets, and so forth, are now sent to the IDP Center There, the data are key-punched into cards which are used for daily updating of the inventory balance records Weekly and monthly reports are submitted to Chattanooga and thus enable close control of material inventories.

Material procurement is correlated with production scheduling. As each new shop order is rough scheduled, the corresponding requisitions for material are assigned realistic dates when the material is required. Weekly IDP reports of items due on requisition, in both item number and requisition number order, permit easy review of the material status by affected groups. The job scheduler can verify the availability of material without continually requesting detail information from the material handling group. Such a determination is necessary efficiently to fine schedule for the start of actual manufacture.

Adoption of the three major work systems, namely: mechanization of payroll procedures, modernization of production controls, and mechanization of material inventory records, has had the effect of improving the over-all efficiency of the Chattanooga Works and enhancing its value as a strong supporting arm of Western Union operations

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[illegible] E. J. TRENT, *Western Union Technical Review*, Vol. 6, No. 2, April 1952

[illegible] Automation and [illegible], WARREN F. WALSH, *Western Union Technical Review*, Vol. 7, No. 4, [illegible]

L. A. Smith joined the Engineering Department in 1929 about a year after receiving his Bachelor degree from Northeastern University. He was actively connected with the design, installation, testing and operation of carrier telegraph systems. In 1946 he was transferred to the P. & E. Department where he continued his carrier work. In 1950 he was assigned to Industrial Engineering work in the office of the Planning Engineer and in 195[illegible] he was transferred to the newly created Industrial Engineering Department

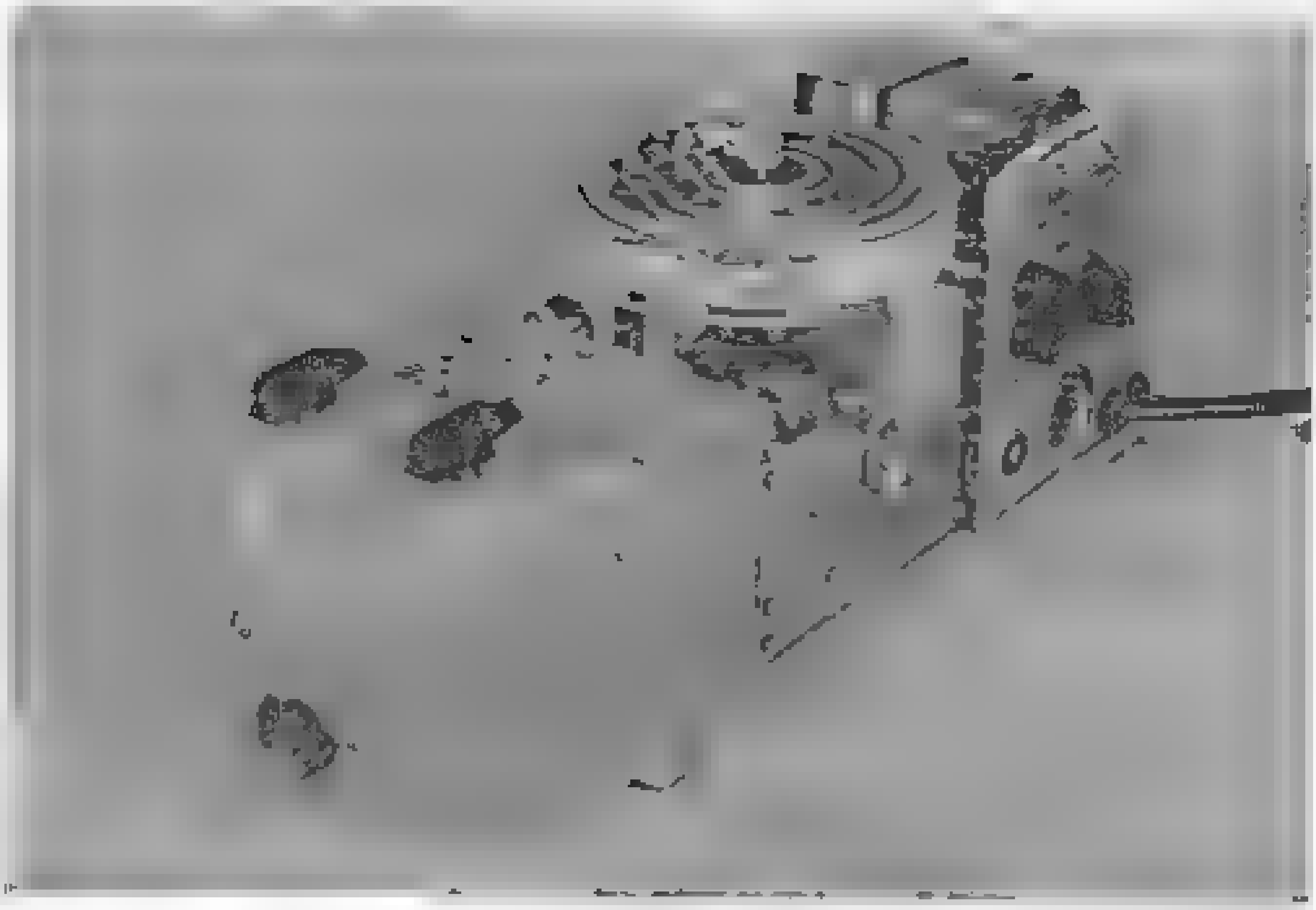


Photo R-11,434

P. F. RECCA, Project Engineer, Apparatus

Bias and Distortion Test Set 7399-A

A versatile instrument which will generate test pulses representative of the variety of less than perfect signals normally flowing in telegraph circuits is in use for testing and adjusting teleprinters, bias and distortion meters and telegraph circuits at approximately 60, 75 and 100 words per minute. As the name indicates, it is a test set with distributor-transmitter and controls; it does not directly measure bias or distortion.

Distortion of telegraph signals occurs, in varying degrees, in all telegraph transmission lines. The inductive and capacitive effects on the signals are kept to a minimum and the distortion resulting from improper transmission is periodically checked and corrected, but the apparatus which is to receive and interpret the telegraph signals into intelligible characters must be capable of operating unerringly on a reasonable amount of random or fortuitous distortions which are not normally controllable. The receiving apparatus must, therefore, be designed and adjusted to tolerate such distortions.

The usual method of measuring the selector margin on a teleprinter, or other receiving apparatus, is to transmit nearly perfect signals to it and maladjust the range scale of the teleprinter to determine the limits of the range scale settings which will permit satisfactory operation. The range scale is then set at the midpoint of these two limits. To duplicate actual service conditions, the range scale should be set at the midpoint of the range and a test set used to generate test signals to the teleprinter which contains all types of distortion normally encountered in telegraph transmission. Bias and Distortion Test Set

7399-A, shown in the frontispiece, was designed primarily to fill the need for a portable device which is capable of transmitting test signals containing a predetermined type and amount of distortion for the purpose of testing and adjusting teleprinters as well as bias and distortion meters and telegraph circuits

The test set is a distributor-transmitter which transmits from a perforated tape either single current (make-break) or polar test signals containing either bias or end distortion. The distortion transmitted can be either marking or spacing and can be varied from 0 to 50 percent by means of a simple manual adjustment. The unit can be readily adjusted to accommodate either chad or chadless tape with either in-line or advanced feed holes. The tape used may be 11/16- or 7/8-inch wide. In the case of 7/8-inch tape, the printing may be across the top edge, as in Western Union's 7/8-inch tape, or across the bottom edge of the tape. The test set can also transmit a continuous "R" or a continuous "Y" without the use of tape. The code transmitted is the 7.42-unit telegraph code. The test set is equipped with a gear shift mechanism to permit rapid selection of transmitting speeds of 368, 460 or 600 characters per minute

Gear System

The mechanical power required to operate the test set is developed by an 1800-rpm synchronous motor which, through a gear reduction system, drives the main shaft of the test set from which all the mechanical operations of the unit are performed (Figure 1)

The intermediate shaft is driven at 600 rpm directly from the motor pinion. A slotted sleeve, on which a gear is mounted, is freely mounted to the intermediate shaft to permit lateral motion but is rotated positively by means of a pin which is press-fitted into the shaft to engage with the slots of the sleeve. An idler gear which meshes with the sliding gear is mounted on a gear change link so that it may mesh with any of the three transmission speed gears on the main shaft while maintaining engagement with the sliding gear. To prevent the possible stripping of gears by changing transmission speeds while the motor is rotating under power, a microswitch, which is wired in series with the

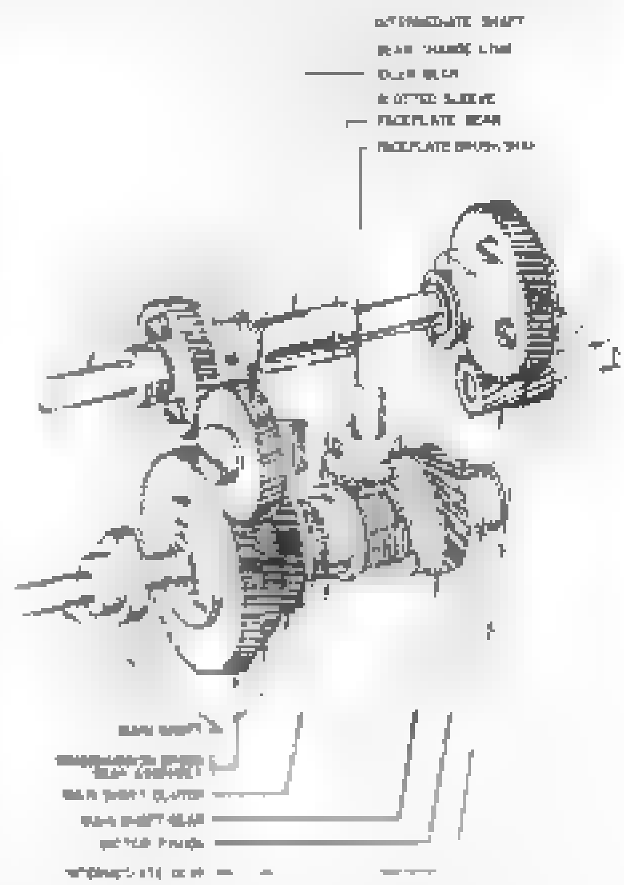


Figure 1. Gear system

main motor switch on the front of the unit, opens the motor circuit while changing to another transmission speed, and closes the circuit only when the idler gear is properly meshed with any of the speed gears.

The main shaft clutch permits manual control of the main shaft from the front of the test set. When the test set is in the stop position, the clutch on the main shaft is disengaged and the three transmission speed gears, which are fastened together, are free to rotate on the main shaft. The driving portion of the main shaft clutch is fastened to the transmission gear assembly and, when engaged by the driven member, rotates the main shaft at 368, 460 or 600 rpm for transmission speeds of 61-1/3, 76-2/3 or 100 wpm, respectively depending upon which of the three gears is engaged by the idler gear

Faceplate

Rotation of the faceplate brush shaft is effected by the meshing of the gear on the

faceplate shaft with the gear which is fastened to the main shaft (Figures 1 and 2). A one-way or over-running clutch on the faceplate shaft permits rotation only in the clockwise direction to prevent fraying of the braided copper brushes due to counterclockwise rotation. This clutch also acts as a detent for the main shaft. The brush assembly, which is mounted to the faceplate brush shaft, has four braided copper brushes which travel over four concentric faceplate rings. The outer segmented ring can be moved angularly for the transmission of distorted signals. The distortion arm is fastened to the movable ring mounting and can be locked at any desired setting on the distortion scale by means of the thumb screw

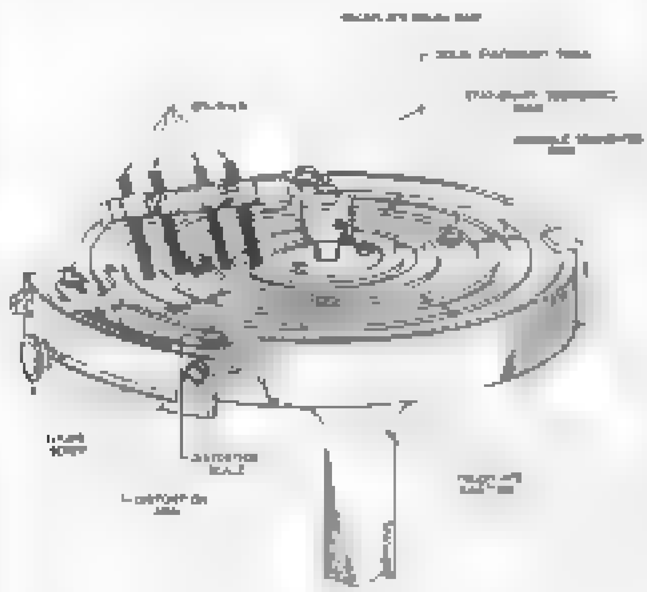


Figure 2. Faceplate

Tape Sensing

The transmitter cam located on the foremost part of the main shaft actuates the pin lever (Figure 3). A pin bail fastened to the pin lever operates the five transmitter pins When the pin lever roller is on the high part of the cam the pin bail pulls the five pins downward to the spacing position As the transmitter cam rotates, the pin bail allows the transmitter pins to move upward under the load of their individual tension springs. If there is a perforated hole in the tape above a pin, the pin will pass through the hole and make contact with its associated contact spring (marking position) which will complete a circuit to the appropriate segments on the faceplate If there is no perforation above a pin, the tape restricts the pin from moving to its marking position and the pin fails to make contact with its contact spring. When the main shaft clutch is disengaged (stop position of test set) the pin lever is on the high part of the transmitter cam, the transmitter pins are held in their spacing position and the brushes will stop on the rest segments of the faceplate

Feed Mechanism

The feed lever which is oscillated about its pivot stud by the feed cam provides motion for the feed pawl which, by engaging a tooth on the feed ratchet. rotates the feed shaft one character for every

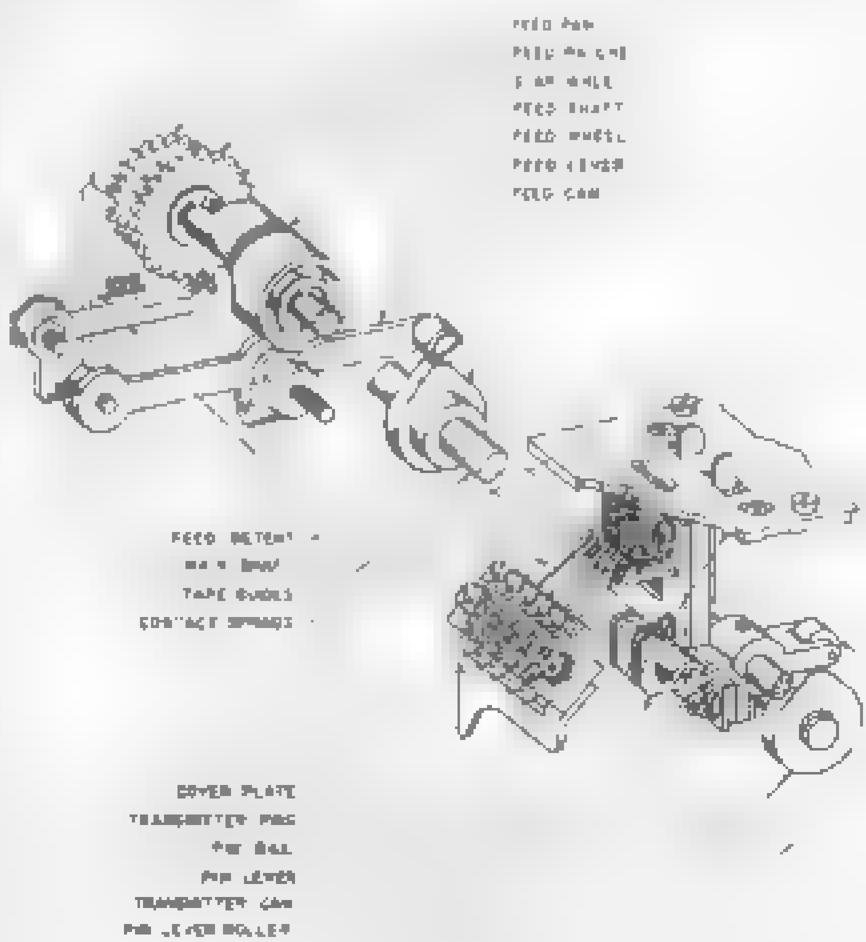


Figure 3. Tape sensing and feed

revolution of the main shaft. A spring-loaded detent in contact with the star wheel on the feed shaft assures positive indexing of the feed shaft. The feed wheel (an integral part of the feed shaft) translates this indexing to the tape by means of pins which fit in the feed holes of the tape. The feed cam is so located with respect to the transmitter cam that the feeding of the tape will occur when the transmitter pins are flush with or slightly below the tape to prevent tearing the tape.

Teleprinter Code

The signal code transmitted by the test set consists of a train of seven pulses, the first of which is always a spacing (no current) pulse. This pulse is usually called the start pulse because it releases the receiving mechanism of the teleprinter and permits the shaft to rotate. The succeeding five pulses are called the code pulses and each of these is equal in duration to the start pulse but may be either a marking (current) pulse or a spacing pulse. The marking and spacing arrangement of the five code pulses will determine the character which is to be selected in the teleprinter. The final pulse in the signal train is always a marking pulse. This pulse stops the rotation of the receiving shaft until the start pulse of the next signal train is received and, for this reason, it is usually called the rest or stop pulse. The duration of the rest pulse is 1.42 times the duration of any one of the other six pulses for transmission speeds of 368, 460 and 600 characters per minute which are used in Western Union telegraph systems. In such instances the code is commonly referred to as a 7.42-unit telegraph code. If the rest pulse is equal in duration to each of the other pulses, the code is referred to as a 7-unit telegraph code. The 7-unit code is used for the transmission speed of 390 characters per minute. Since the only difference between the 7- and 7.42-unit codes is in the rest pulse, the speeds of 390 and 368 are completely compatible. The test set, which is capable of transmitting 368 characters per minute, would also be suitable for testing teleprinters equipped for 390-character-per-minute transmission.

In single-current signals, only marking pulses can be distorted since a spacing pulse is merely the absence of current. A marking pulse can be distorted at the beginning or at the end of the pulse. A signal train of perfect signals is shown in Figure 4 (A). The pulses 1 through 5 are the code pulses which may be marking, such as pulses 1, 3 and 4, or spacing, such as pulses 2 and 5. The rest pulse, "R", and the start pulse, "S", are also shown as marking and spacing pulses, respectively. Since the beginning of each start pulse releases the selector mechanism and allows it to rotate, the signal transition from the rest pulse to the start pulse is used as a reference point to which all other signal transitions can be compared.

Bias

Bias is the type of distortion in which the beginning of each marking pulse is either advanced or delayed with respect to the beginning of a start pulse. If the space-to-mark transition is advanced, the effect is to lengthen the marking pulses and shorten the spacing pulses. This type of bias is called marking bias. If the space-to-mark transition is delayed, the marking pulses are shortened and the spacing pulses lengthened. The resulting distortion is called spacing bias. Marking and

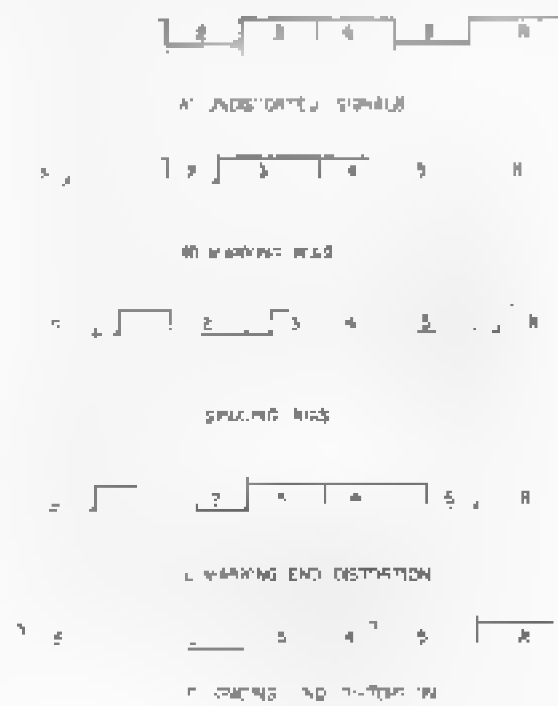


Figure 4. Types of signal distortion

spacing bias signals are illustrated in Figures 4(B) and 4(C), respectively

End Distortion

End distortion is the type of distortion in which the marking pulse is either lengthened or shortened at the end of each marking pulse with respect to the beginning of a start pulse. If the mark-to-space transition is delayed, the effect is to lengthen the marking code pulses and shorten all spacing code pulses. This type of distortion is called marking end distortion. If the mark-to-space transition is advanced, the effect is to shorten the marking code pulses and lengthen all spacing code pulses. This is called spacing end distortion Marking and spacing end distorted signals are illustrated in Figures 4(D) and 4(E), respectively Note that the rest and start pulses for end distortion are of the same duration as those for undistorted signals. This is not a condition which is normally encountered in telegraph circuits since inductance and capacitance will affect all of the signals in the train. The transmission of end distortion for test purposes makes it possible to determine the tolerance of a receiving mechanism to random or fortuitous distortions which do not affect all transitions alike.

Generating Distorted Signals

Distorted signals are generated in Bias and Distortion Test Set 7399-A by the use of a special faceplate consisting of one fixed segmented ring and one movable segmented ring which can be rotated about the common center of the two rings. As the distributor shaft rotates, each segmented ring is electrically connected in turn to an associated solid ring by means of a brush assembly. The brushes are mounted on a common brush arm, so that all four brushes are in alignment. The movable ring can be rotated through an angle equal to one-half the angle subtended by a code segment and locked in position by means of a thumb screw. This permits adjusting the amount of distortion from 0 to 50 percent. A scale on the faceplate assembly indicates the percent of distortion for which the unit is set

If the segments on the movable ring are electrically connected in series with the segments on the stationary ring, the line signal circuit will be completed only when the brushes are in contact with a segment on the movable ring and its corresponding segment on the stationary ring. When the segments on the movable ring are connected in parallel with the corresponding segments on the stationary ring, the line circuit will be completed when the brushes are in contact with either segment. A manually operated distortion selector switch permits the electrical wiring to be switched to the desired type of connection to obtain either marking or spacing bias, undistorted signals, or either marking or spacing end distortion.

Bias Setting

Figure 5-A shows schematically the electrical connections established when the distortion selector switch is set on "marking bias." This figure shows reading transmitter pins Nos. 1, 3 and 4 in the marking position and Nos. 2 and 5 in the spacing position Each code segment and the rest segment on the movable ring are connected in parallel with their corresponding segments on the stationary ring Thus, the circuit through the line plug is completed when either pair of brushes is in contact with its associated rest segment. When both pairs of brushes are in contact with the two start segments, the circuit is opened and a spacing pulse is transmitted to the line. As the brush assembly rotates, the brush on the movable ring makes contact with the No. 1 segment and the line circuit is completed from the sleeve of the line plug to the inner solid ring, through the brush arm to the No. 1 segment on the movable ring, through the No. 1 contact back to the tip of the line plug. As the brush assembly continues to rotate, the brush on the movable ring leaves the No. 1 segment and contacts the No. 2 segment. The circuit is not opened, however, as long as the brush on the stationary ring is in contact with its No. 1 segment. Under this condition

the circuit is completed from the sleeve of the line jack to the outer solid ring, through the brush arm to the No. 1 segment on the stationary ring, through the strap to No. 1 segment on the movable ring to the No. 1 pin and contact and back to the tip of the line plug. When both brushes contact their No. 2 segments the circuit is opened at the No. 2 contact. The signal train transmitted for the letter "F" combination set up on the transmitter pins is shown beneath the schematic wiring. The pulses are shown oriented in correct relationship to the faceplate segments.

The circuit connections for transmitting spacing bias are shown in Figure 5-B. When the distortion selector switch is set for spacing bias, each code segment and the rest segment on the movable ring are connected in series with their corresponding segments on the stationary ring. Under these conditions, a start pulse will be transmitted when either brush is on its associated start segment. A rest pulse will be transmitted only when both brushes are on their associated rest segments unless the No. 5 pulse is a marking pulse. Also, a marking code pulse will be transmitted only when each brush is on a marking code segment.

End Distortion Setting

The electrical connections established when the distortion selector switch is set on "marking end distortion" are shown in Figure 5-A. In this case the start and rest segments on the stationary ring are not used and there are no connections to these two segments. The code segments on the stationary ring are connected in parallel with the code segments on the movable ring. Thus, the start and rest segments are undistorted but the code segments which are marking are lengthened, just as in the case of marking bias.

The electrical connections established when the distortion selector switch is set on "spacing end distortion" are shown in Figure 5-B. In this case the start and rest segments on the movable segmented ring are not used and are, therefore, undistorted. The code pulse segments on the stationary ring are connected in series with the corresponding segments on the movable ring. Thus, code pulses which are marking are shortened, as in the case of spacing bias.

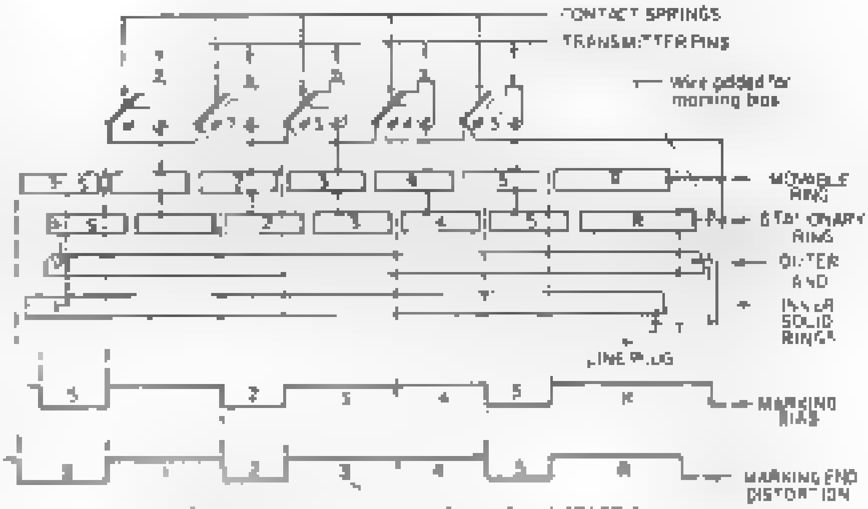


FIG. 5-A MARKING BIAS AND MARKING END DISTORTION

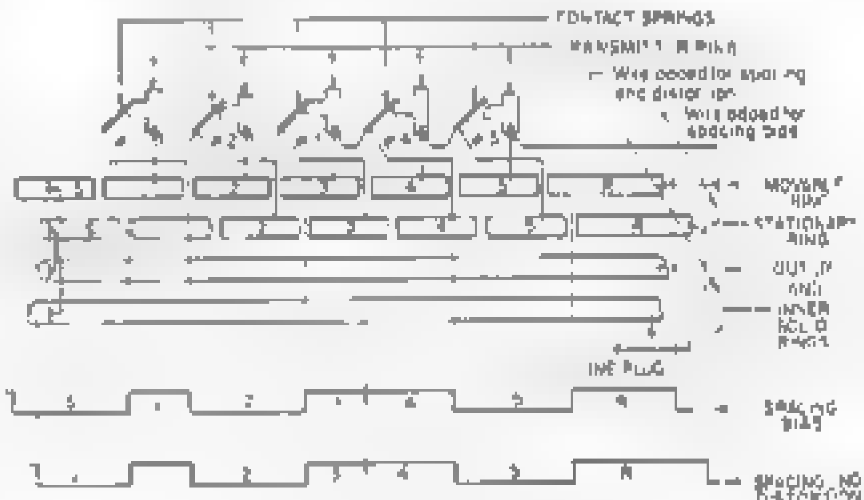


FIG. 5-B SPACING BIAS AND SPACING END DISTORTION

Figure 5. Single-current signal distortion currents

Normal Signal Setting

Undistorted signals are transmitted when the distortion selector switch is set on normal signals. At this setting, the electrical connections to the contact springs and the transmitter pins are identical to

those shown for marking bias transmission in Figure 5-A, but all connections to the segments of the stationary ring and the outer solid ring are removed. Since only the connections to the movable ring and the inner solid ring remain in the circuit, perfect signals will be generated by the test set.

"R-Tape-Y" Switch

When the R-Tape-Y switch is set on "R," the No. 2 segments on the faceplate are electrically connected to the jack plug without going through the No. 2 transmitting pin and its associated contact. The No. 4 segments are also electrically connected to bypass the No. 4 pin and contact. The circuits to the Nos. 1, 3 and 5 segments are opened at the R-Tape-Y switch. Thus, letter "R" will be transmitted each time the brush arm rotates whether or not there is tape in the transmitter. Similarly, when the R-Tape-Y switch is in the "Y" position, the letter "Y" will be transmitted each time the brush arm rotates. When the switch is in the "Tape" position the circuits through the distributor segments are completed through the associated transmitting pins and contacts so that the perforations in the tape will determine the characters transmitted.

Polar Signals

In order to transmit polar signals (Figure 6) from the test set it is necessary to supply positive and negative battery to the polar battery jack. Marking battery must be applied to the tip of the jack and spacing battery to the sleeve. The "Make-Break-Polar" switch must be set on "Polar." Also, 120 volts direct current must be supplied to the polarized receptacle on the test set in order to furnish direct current for operating the polar relay. A polarity reversing switch is provided in the test set so that either polarity of battery can be used for operating the relay.

When the test set is set for polar transmission, make-break signals from the faceplate are transmitted to the operating winding of the polar relay. The current in

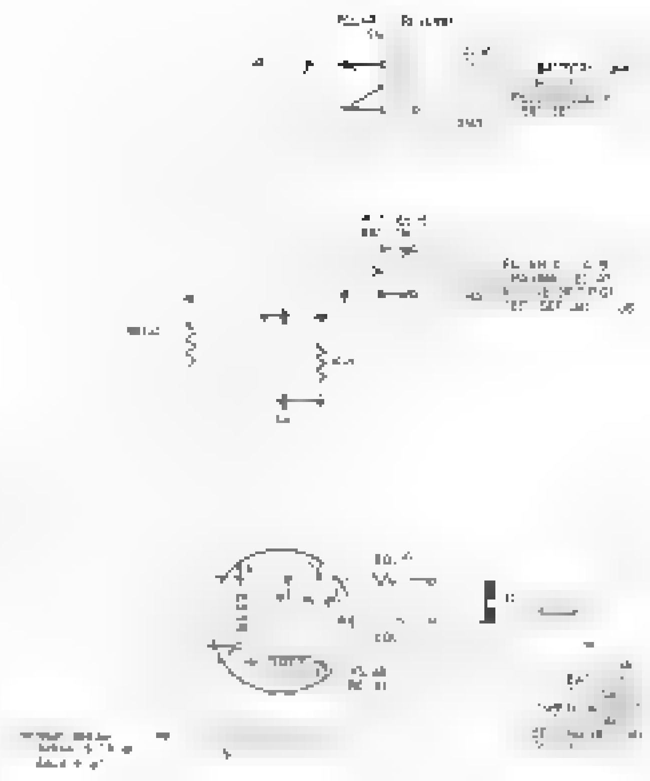


Figure 6. Polar signal circuit

the bias winding of the relay is such that undistorted signals are produced by the relay. The polar signals appearing on the tongue of the relay can be connected either to the tip or to the sleeve of the test set jack plug by means of the "Tip-Sleeve" switch.

Adjusting Teleprinters

When a teleprinter is maladjusted, it is subject to internal distortions which reduce the operating margin of the selector mechanism. After all other adjustments in a teleprinter are properly made, the proper balance between the selector armature spring and the magnet air gap must be established for the line current on which the teleprinter will be operating. Since the spring and air-gap adjustments given in the adjustment specifications of the teleprinter were developed by taking the average of a large number of teleprinters, they do not necessarily result in optimum adjustments for each teleprinter due to variations between teleprinters. If the magnet air-gap is not properly adjusted so that the pull of the magnet is in proper balance with the armature spring tension, internal bias will result. If the armature spring load is not of the proper

magnitude, erratic operation of the selector armature will occur which will result in internal skew. All teleprinters should be so adjusted that the internal bias and skew are below 3 percent.

When initially adjusting a teleprinter for the elimination of bias and skew, the armature spring tension and air gap are adjusted in accordance with the specifications for the teleprinter. The teleprinter and the Bias and Distortion Test Set 7399-A are then connected into a local test circuit which has the same line current as in the actual operating condition of the teleprinter. Since wave-shaped signals affect the internal bias of the teleprinter, no wave shaping should be used in the test circuit. A prepared test tape is then inserted in the test set and a fixed amount of spacing bias is transmitted to the teleprinter and a range taken. The same amount of marking bias is then transmitted and the range again measured. The internal bias and skew are then calculated as follows:

$$\text{Bias} = \frac{(H_s - L_s) - (H_m - L_m)}{2}$$

$$\text{Skew} = \frac{(H_m - L_s + 2D) - (H_s - L_m)}{2}$$

Where H_m = high end of marking bias range

L_m = low end of marking bias range

H_s = high end of spacing bias range

L_s = low end of spacing bias range

D = percentage of distortion in transmitted signals

Positive bias indicates internal marking bias and negative bias indicates internal spacing bias. Positive or negative skew in a teleprinter is the result of irregular operation of the selector armature, or some other selector member, from the marking to the spacing position or from the spacing to the marking position, respectively.

If a teleprinter has internal skew greater than plus or minus 3 percent, the skew should be removed first by adjusting the armature spring. Positive skew can be reduced by increasing the armature spring tension and negative skew can be reduced by decreasing the spring tension. After the internal skew has been reduced to 3 percent or less, the internal bias should be reduced to 3 percent or less by adjusting the armature air gap. Negative bias can be reduced by decreasing the air gap and positive bias can be reduced by increasing the air gap. The range scale should then be set at the center of the bias range. This center is found by the following formula

$$\text{Bias Center} = \frac{H_m + L_s}{2}$$

With the range scale set at this point, a teleprinter which is geared for 368 or 390 operations per minute should print correctly when signals containing 40 percent marking or spacing bias are transmitted to it. It should also print correctly on signals containing 35 percent marking or spacing end distortion. Teleprinters geared for 460 or 600 operations per minute should operate satisfactorily on signals containing 35 percent marking or spacing bias and 30 percent marking or spacing end distortion.

A receiving unit geared for 368 or 390 operations per minute and adjusted in accordance with the foregoing method will usually have a range of at least 80 points on undistorted signals. Ranges of 85 to 90 points are not uncommon. However, ability to operate satisfactorily on distorted signals is a far more important test of a receiver than its range on undistorted signals.

Testing and Calibrating Bias and Distortion Meters

Bias and Distortion Meter 6838-A, which is commonly used in Western Union, measures bias by the measuring of the average length of a discrete spacing pulse. A discrete spacing pulse is one which is both preceded and followed by a marking pulse. To calibrate the bias scale on the meter, a continuous "R" or "Y" is transmitted with marking bias and then with spacing bias. The meter is adjusted to

correspond to the percentage of bias transmitted

The bias and distortion meter measures distortion by measuring the decrease in length of a discrete spacing pulse as compared to the average of discrete spacing pulses. Although the test set is not normally capable of transmitting such distortions, the following procedures will simulate the conditions to which the distortion meter is sensitive

Select the amount of distortion to be transmitted by the test set for calibrating the distortion meter. With undistorted signals selected on the distortion selector switch of the test set, transmit a continuous "R" or "Y" to the meter for a few moments. Then, without interrupting the transmission by the test set, select marking biased signals on the distortion selector switch of the test set. The distortion meter will rise to the percentage of marking bias previously selected.

Since the test set is also capable of transmitting polar signals, the polar signal feature of the bias and distortion meter may also be checked

Other Applications

Bias and Distortion Test Set 7399-A can be used to determine the over-all operating margin of a telegraph circuit by transmitting either perfect or distorted signals over a telegraph line to a properly adjusted teleprinter or bias and distortion meter. In this manner line distortions may be accurately determined and corrected

The test set may be used as a portable master distributor-transmitter which can be plugged into any transmission line, regardless of transmission speed, for the purpose of determining whether the erroneous reception by telegraph apparatus is due to faulty receiving on transmitting equipment

Reduction of maintenance trouble calls on mechanical apparatus may be effected with the use of the test set by transmitting a predetermined minimum tolerance to distorted signals by the receiving apparatus of outstations. This preventative maintenance procedure may determine many of the impending troubles in the equipment and effectively reduce the amount of emergency maintenance calls

A biographical sketch of the author appears in the April 1957 issue of TECHNICAL REVIEW

ALDER F. CONNERY, General Supervisor—Applied Engineering

Neutralization of Static Electricity—I

Static electricity interferes with rapid movement of paper tapes and message blanks in automatic telegraph systems. Of various methods used to disperse static charges, one which produces neutralizing ions by high-voltage corona discharge from needle points has been found practical, safe and inexpensive. But first

IT IS A familiar fact that paper and other materials in dry weather can become electrified and will have a strong tendency to be attracted to other objects and to remain attached to them with considerable force. The problem of static electricity is severe in many industries and a drop in production and an increase in the spoilage of the product is often evident during periods of low humidity

Static electricity is a very old subject and the first written notice of this electrical action appears to have originated 600 years before the Christian era, with Greek philosopher Thales, founder of the Ionic philosophy He observed that amber, when subjected to slight friction, acquired a power of attraction and would draw light bodies to it. The attractive power of amber when rubbed may be considered as the basis of our electrical nomenclature, the Greek word denoting amber being elektron, in Latin electrum. The unknown element which, according to Thales, gave it life has been termed electricity

The scientific books on electricity written about a century ago devoted many pages to the subject of static electricity and how it is produced. Little was written on how to avoid or neutralize it but this may be due to the fact that it was not such a troublesome factor in industry as it then existed.

In some industries, depending upon the type of materials being used in the processing, fires and explosions are some of the worst effects of static electricity. In the telegraph industry, however, static electricity if not controlled can introduce reduced efficiency of operation of automatic equipment and delays to traffic movement by reason of the energized paper telegraph blanks and perforated tape adhering to contiguous surfaces.

A piece of paper, for example, which exhibits electrification may have either a positive or a negative charge. The early experimenters found that when certain dissimilar substances are rubbed together one would acquire a positive charge and one a negative charge. From these experiments an electrical series was developed Such a series, listing common materials, is given in Table I.

TABLE I — ELECTRICAL SERIES

1. Fur	8. Paraffin wax
2. Flannel	9. Ebonite
3. Ivory	10. The hand
4. Glass	11. Metals
5. Cotton	12. Sulphur
6. Paper	13. Celluloid
7. Silk	14. Rubber tubing

When one substance is rubbed with another substance the one with the lowest number in the above series will acquire a positive charge and the one with the highest number will acquire a negative charge. It should be noted, however, that the relative charge is dependent more upon the condition of the surface of the material rather than the material itself A soiled ebonite rod for example, may exhibit somewhat different characteristics than a clean rod.

Experiments have shown that the amount of electrification developed is the same whether sliding friction is employed or whether it is rolling friction. It has been found that all bodies that have been pressed together, if properly insulated, offer signs of electrification on being separated, although the effect is most easily observed between a good conductor and a bad one The two bodies are always in opposite states. Even when two disks of the same substance are pressed together, if one be a little warmer than the other, distinct excitement is produced, the warm disk becoming negatively electrified The intensity of the charge increases as the pressure is increased.

It has also been found that hammering insulated bodies will cause a charge to

develop and this is particularly true when actual shearing occurs. In a reperforator, for example, the initial charge may develop as the tape is unwound from the roll. Subsequently, the tape rubs against metal and other surfaces and acquires more charge. The shearing action of the perforator pins adds to the charge. Even if a static eliminator is used to completely remove the charge from the paper as it leaves the perforator, charges will be added as the tape slides over the tape guides and tape accumulator, and even the pounding of the pins and the sliding action through the tape transmitter will build up a fairly strong charge. In some cases it has been found necessary again to discharge the paper after it leaves the tape transmitter to insure that it will reliably fall into the sent tape receptacle.

Paper has a lower number in the electrical series than substances such as metals or rubber tubing. The paper in a typewriter or a perforator is most likely to rub against metal or rubber surfaces and therefore always acquires a positive charge.

For a proper understanding of the electrification of paper and the various methods of combatting it some knowledge of the behavior of atoms is necessary. Every atom consists of nuclei, protons and electrons. The quantity will vary depending upon the type of atom. The nuclei have no electrostatic charge. Each of the protons carries a positive charge. In the normal atom there are as many electrons as there are protons and each electron will have a negative charge that will be equal and opposite in value to the charge on each proton. The normal atom will, therefore, have no net charge. The outermost ring of electrons is rather loosely bound to the atom and friction or strong electric fields can cause an atom to lose one of its electrons. An atom that has lost an electron will have a net positive charge and is called a positive ion. The free electron exhibits a negative charge and it is, therefore, called a negative ion. An ion is simply a particle that has a net positive or negative electrical charge. The free electron may finally become attached to a neutral atom and this atom will then have acquired a negative charge and the whole will be called a negative ion.

A sheet of paper that exhibits no outward evidence of electrification may be composed not only of ordinary or neutral atoms but may also have many positive and negative ions. If the number of positive and negative ions in any relatively small area are in numerical balance the paper will have no tendency to stick to other unelectrified materials. If, however, the paper, for example, has more positive than negative ions it will then be positively electrified and will be attracted to other materials.

During damp weather there is appreciable electrical conductivity through the paper and if it is in contact with grounded metal or other material having conductivity to ground the charge on the paper will quickly leak away. The leakage is primarily through the material in contact with the paper and not directly through the moist air, unless the air is highly ionized.

It is known from experience that static is not much of a problem when the relative humidity in the offices is on the order of 40 percent or greater. Under those conditions any induced charge will quickly leak from the paper. At relative humidities of less than 40 percent some trouble may be expected and when the humidity becomes less than 20 percent static troubles will become really serious. Relative humidity conditions of under 20 percent are quite common during the heating season in cold climates. There are some areas such as Colorado or southern California where extremely low relative humidity conditions occur even during the summer months.

It has been suggested that air conditioning be used to maintain the necessary high humidity. In addition to the high installation and operating expense other troubles will manifest themselves during the cold weather. Moisture will condense upon windows and walls and cause damage. Also, the personnel will complain of "drafts" unless a rather high air temperature is maintained. Humidification of the air by one means or another is helpful but it is by no means the final solution to the problem.

It has been observed that some types of paper are more likely to acquire and hold a static charge than others. It has been noticed that folded printer paper, by the nature of its dispensing, will not pick up as great a static charge as paper being unreeled from a tightly wound roll. The finish of the paper has a bearing on the charge collected; smooth finish papers seem to pick up less charge than rough paper and a stiff sheet will pick up less charge than a thin flexible sheet.

It has been suggested that hygroscopic agents be added to the paper to make certain that enough moisture will remain in the paper to insure that any charge will quickly leak away. It has been found that a sufficient amount of hygroscopic agent, that will be really effective in a very low humidity atmosphere, is likely to cause paper handling troubles of a different sort during periods of extremely high humidity. One type of paper would, therefore, not be suitable for both high and low humidity conditions and this presents serious difficulties in supply and use.

The most effective method of neutralizing a static charge on paper is by some means to produce ions in the immediate vicinity of the charged paper. If, for example, the paper has a positive charge, negative ions in the vicinity will be attracted to the paper and will lie on its surface and bring the paper into equilibrium. Similarly, if the paper has a negative charge, positive ions in the air in the vicinity of the paper will be attracted to it and these positive ions will become attached to the surface of the paper and will neutralize the static charge.

There are a number of methods employing various devices that may be used to dissipate or neutralize static charges and some of these are as follows:

- Radioactive neutralizers
- Ultraviolet light
- Grounded needle points
- Stretched wires
- [redacted]
- Hot metals
- High-voltage needle points

Radioactive Neutralizers

Radioactive neutralizers have been used as a producer of ions in some industries to combat static. Where it is practical effectively to shield the radioactive elements and when proper care is used in the handling of these units, quite satisfactory results have been obtained. Radium-bromide is one form of the material that has been commonly used for this purpose. Radium has a very long life and takes over 1600 years to diminish to half-strength. The radium continuously produces alpha, beta and gamma rays. The alpha rays have great ionizing power but little penetrating power, and it is the alpha rays that are most effective in static neutralization. The beta and gamma rays have less ionizing power but greater penetrating power and this necessitates the use of the minimum quantity of radium together with adequate shielding. The following Table II gives an approximation of the ratios of the ionizing and penetrating powers of the rays.

TABLE II

	Alpha Rays	Beta Rays	Gamma Rays
Ionizing power	10,000	100	1
Penetrating power	1	100	10,000

The alpha ray is the nucleus of the helium atom and carries a double positive charge. It is relatively heavy and is a definite particle of matter. Its range varies from one to three inches from the source. It is stopped by extremely thin films of material. A sheet of ordinary paper will completely absorb the radiation. The alpha ray can produce an intense field of ions along its relatively short path in air.

The beta ray is nothing more or less than ordinary electrons which are emitted at a very high velocity from the source. Ordinarily the electrons would be a very good ionizing agent but their initial velocities are so great that they have very little ionizing effect near the source.

The alpha and beta rays can both be deflected by magnetic and electric fields. The gamma rays are not definite particles, such as the alpha and beta rays, but are more like light rays and are similar to the well-known X-rays.

As the radium decays, radon gas is produced. This gas is not useful for ionizing purposes and should not be allowed to escape into the air since it is radioactive. It has a half-life of only 3.82 days. To prevent the escape of this gas, so-called "sealed sources" are used. A sealed source consists of a backing, for example, of a silver plate on which the radium salt is deposited with a very thin gold foil covering the radium material. The gold foil is firmly attached to the base to prevent the escape of the radon gas. Because of the short life of this gas the pressure will build up to a steady value at which time the amount of radon gas produced in a given interval will just equal the amount that has decayed. The product, radon gas, is then said to be in secular equilibrium with the parent substance.

Polonium has been used as an ionizing material. It has the great advantage that it

gives off only the alpha rays. It has, however, the very short half-life of 138 days and its useful life is only in the order of one year. There is much research now being conducted on radioactive isotopes and some hold promise of being used for static elimination. One radioactive isotope, Krypton 85, has a half-life of ten years and its emanations are practically all alpha rays. Krypton 85 is a gas and for static elimination purposes it is contained in a small thin-walled metal vial. At the present time, however, the rules and regulations concerning the handling and use of radioactive material are extremely difficult to observe and the trend is toward the use of neutralizing means other than radioactive sources. In certain industries, however, when restricted mounting space or ultrahazardous flammable mixtures preclude the use of high-voltage type neutralizers one would expect the continued use of the radioactive methods.

Ultraviolet Lamps

Ultraviolet light rays have an ionizing effect and can be used to neutralize static charges on paper. The action is rather slow, however, and the equipment is bulky. It is also necessary to shield personnel from the rays. As a method for neutralizing static charges it does not appear to be much used.

Grounded Needle Points

The neutralizing effect of a pointed body was first observed by Benjamin Franklin in 1750. He showed that when a pointed conductor was presented to an electrically charged body, the point rapidly caught up the electricity of the charged body even at considerable distances.

If a sheet of charged paper is held, remote from other materials, and a very sharp grounded needle point is brought within a few inches of the paper it will be found that the charge on the paper will be almost entirely dissipated. The high-voltage charge on the paper, which may be as much as 20,000 to 50,000 volts, creates a high-voltage field in the vicinity of the paper and the effect of the needle point, when placed in this field, is to create, at the point of the needle, a voltage-gradient sufficiently great to dislodge by collision electrons from the atoms and thus create positive and negative ions. The ions of the proper polarity will be attracted to the paper and will neutralize the charge. The other ions will be repelled.

There are practical difficulties, however in the way of applying the principle of the grounded needle point to the paper handling problems of the telegraph industry. The grounded needle point does not completely neutralize the charge. There is always a small residual charge left on the paper and this small charge in certain cases can be the cause of paper handling trouble. It is important to know that the actual voltage exhibited by the paper is greatest when the paper is remote from other objects and the voltage is lower when it is near other objects. When in actual contact with other materials there will be very little tendency for the paper to attract ions to it. The reason for this can be simply explained. Consider, for example, the two plates of a condenser in air. If these plates have previously been charged to a certain potential and are then moved apart, it will be found that the capacitance is reduced but the voltage is necessarily increased in order to conserve the stored energy. If the plates are brought very close together but are still not in actual contact, there will be a very great reduction in the potential difference between the plates. A further difficulty in the use of grounded needle points is that many of the ions lodge on nearby surfaces and have no neutralizing effect on the paper. If the sharp needle points are so located that they are a hazard to personnel it becomes necessary to provide some kind of a protective shield and this detracts from the efficiency of the method. In general, it has been found that the most effective static neutralizing methods employ sources that continuously emit positive and negative ions (ion pairs).

Stretched Wires

If the charged paper is pulled over a very small diameter, tightly stretched grounded wire located an inch or so from other material a fairly good job of neutralizing will be done, but in a relatively short time the effectiveness will be greatly reduced due to contamination of the wire from the paper. It is necessary that the wire be frequently cleaned and for that reason this method is not practical in most cases. Apparently, the fine wire along its length acts like the grounded needle point and creates a sufficiently high-voltage

gradient in the electric field of the paper to create by collision the ion pairs necessary for the discharge of the paper.

Flames

An extremely effective method of generating ion pairs is by the use of flame such as an ordinary gas flame. Gas flames have been effectively used in the printing industry to take the static charge from paper. However, the danger of fire is great and this is probably the main reason for this simple method not being more widely used. The extreme heat causes violent agitation in the atoms and some electrons become detached thus creating the ion pairs.

Hot Metals (Thermionic Emission)

Magnetism & Electricity, printed in 1875, has a chapter on the discharge of electricity and gives data on the effectiveness of white-hot iron balls in discharging bodies having either positive or negative charges. It was found, however, that when the balls cooled to a red heat they were effective only in discharging bodies having a negative charge. A similar effect can be observed with an ordinary electric glow heater. Paper having a negative charge when held a few inches from the glowing wires will be neutralized. Positively charged paper, however, will not be discharged. Since paper as it comes from a typewriter or teletypewriter always exhibits a positive charge the glowing wire method would not be useful in the telegraph industry.

High-Voltage Needle Points

Very satisfactory results have been obtained by the use of high-voltage needle points. In actual practice, by means of a step-up transformer, a 60-cycle alternating current at a voltage of 10,000 to 12,000 is applied to one or more needle-like points. The intense electric field at the sharp point causes ionization by collision. If there were no ions initially present in the air surrounding the needle the process would never start but there are always a few stray ions in the atmosphere. The mechanism here involves the acceleration of the charged particles by means of an electric field until they have sufficient energy to produce more ionization in colliding with neutral atoms or molecules. These new ions are also accelerated until they, too, produce ionization by collision. Ions of opposite sign have a natural affinity for each other. Their mutual electrostatic field draws them together and they then recombine. The rate at which this recombination occurs is proportional to the numbers of each kind of ion present. It has been stated that the recombination occurs usually when the negative ions are of molecular size. Recombination can also occur on nearby surfaces. The process is one in which the wall acts as a reservoir holding ions of one sign on its surface until ions of the other sign have a chance to come up and recombine with them to form neutral atoms or molecules.

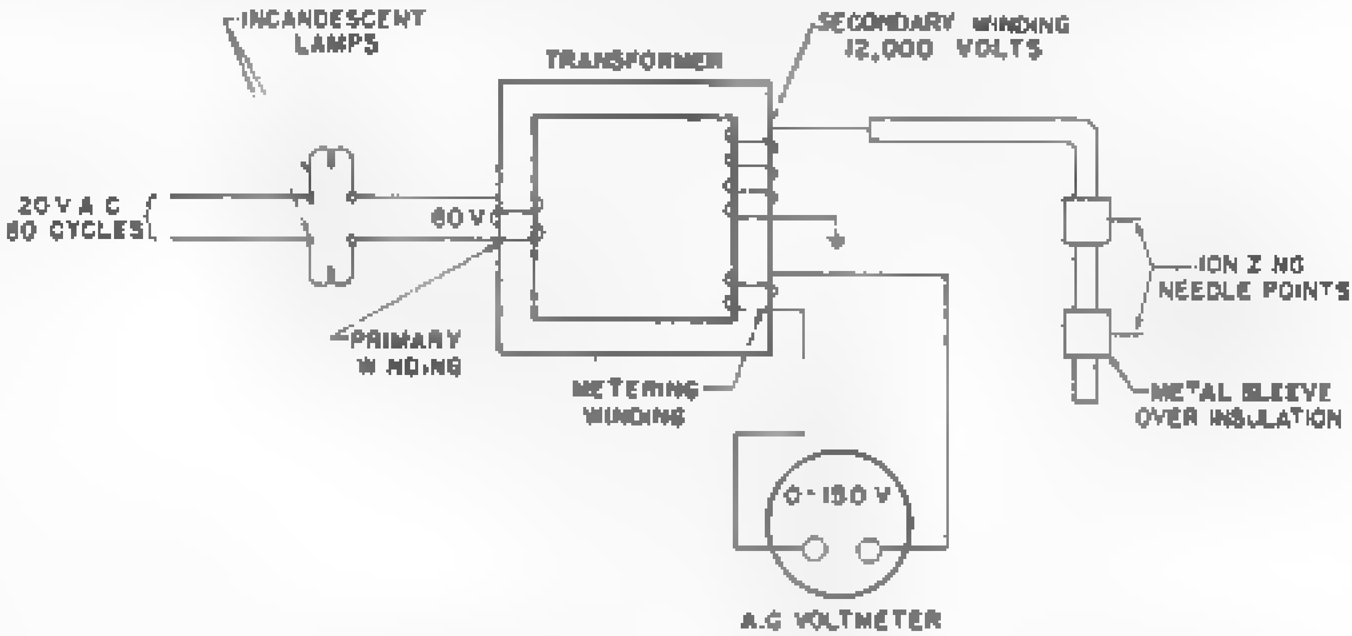
Since the positive and negative ions have a natural affinity for each other, it would be reasonable to expect almost complete recombination near the ion source and therefore there should be little neutralizing effect several inches from the needle points. It is believed that although the electric field extends to infinity, actually when the charged particles are some distance apart the change in velocity due to the electric field is so small in comparison with the total velocity that the effect of the electric field can be neglected. Thus, when the ions are some distance apart, their thermal motions predominate and they may actually be carried away from one another. It has been found experimentally that even from a distance as far as 12 inches from the ionizing needle point there is considerable neutralizing effect.

In the experimental work to date it has been found that complete neutralization is obtained when the needles are energized with high-voltage alternating current. High-voltage direct current can be used but there will always be a small residual charge left on the paper and the polarity of this charge will be dependent upon the polarity of the needle point. A positively charged needle point, for example, will leave a small positive charge on the paper. The probable reason for this is that most of the negative ions will, immediately after generation, be attracted to the positive needle and wire connecting thereto.

Most of the ions in the vicinity of the needle will therefore be positive ions and they will be quite effective in neutralizing paper with a negative charge. However, because of the fact that the paper that is being discharged is in a positive electric field, there will come a time when the paper is apparently in balance and no more ions will be attracted to it, but when the paper is removed from the electric field it will be found to have a small residual charge on it. The use of alternating current tends to produce ions of the two polarities in more or less equal quantity and there is no residual charge on the paper as a result of the electric field because the field is constantly changing in polarity and the paper, in the normal application of the static eliminators, slowly enters and withdraws from the field. There is, therefore, no tendency for the paper to leave the influence of the ionizing needle with a residual charge.

The high-voltage ionizing needles when energized produce a very faint corona glow. This violet-colored glow can be seen only in a very dark room and is extremely faint. The glow is caused by the energy given off by atoms which are returning from an "excited" to a "normal" state. An extremely small amount of ozone gas will also be produced at each needle point. This ozone gas is produced in a very minute quantity and is not harmful.

The high-voltage ionizing needle-point method when properly installed is in no way a hazard to personnel even though the voltages are far greater than is usual in telegraph installations. The transformer installation is made in such a manner as to make it impossible to get a dangerous shock from the high-voltage secondary because the maximum possible current is held to a relatively low value. The needle points themselves are never directly connected to the copper wire but are indirectly coupled through the insulation which acts as a capacitor of extremely low value. When the energized needles are touched with the hand no shock whatever can be felt.



The illustration shows a schematic drawing of a typical installation such as used on a system involving a multiplicity of reperforators and transmitters.

The primary winding of the transformer, it will be noted, is not directly connected to the 120-volt a-c circuit but is connected through a pair of ordinary tungsten lamps. The actual voltage on the primary is limited by the resistance of the lamps to about 60 volts. The turns ratio between the primary and secondary windings in such a transformer would be 1:200. With 60 volts on the primary the secondary voltage would be 12,000. In order to know at all times what the secondary voltage is, a so-called metering winding is used that is wound on the same leg of the transformer as the secondary. The metering winding is directly connected to an a-c voltmeter with a scale of 0-150 volts. Since the turns ratio between the metering and secondary winding is 1:100, the reading of the voltmeter is simply multiplied by 100 to obtain

a close approximation of the secondary voltage. This metering winding scheme avoids the use of expensive bulky high-voltage meters.

The actual power consumed by each ionizing needle is infinitesimal. The reactive current from the transformer is appreciable, however, because of the capacity coupling between the high-voltage wires and nearby surfaces. The current in the primary is nevertheless comparatively small and in the normal installation the value of the resistance lamps would be such that under no circumstances could there be a primary current in excess of one ampere. Since the ratio of the turns between the primary and secondary is 200 it should be evident that the maximum possible current from the secondary would be only 1/200 of the primary current, or in no event in excess of 0.005 ampere, and that amount of current would not be considered hazardous. Metal filament lamps have been used in the primary circuit of the transformer rather than ordinary resistors because the metal filament lamps have the characteristic of increasing their value of resistance as the current increases. This helps in reducing the maximum current that can possibly flow from the secondary.

Part II of this article is to be published at an early date and will cover in detail the actual form and installation of the high-voltage ionizing needle system. Certain important principles must be observed if the system is to be effective and these principles will be explained.

A biographical sketch of the author appears in the January 1959 issue of TECHNICAL REVIEW

Telecommunications Literature

Telegraphy, a new technical book of 738 pages published by Pitman in London, touches every important facet of the telegraph art from its inception until the recent past. Offered as successor to T. E. Herbert's classic *Telegraphy*, it merits attention here because it is the first comprehensive telegraph textbook to be printed in English in many years.

The author, J. W. Freebody, is staff engineer, British Post Office Engineering Department. Although apparatus described is for the most part of British Post Office design, the principles brought out are, of course, universal. Various telegraph system components, systems and system theories are detailed; transmission theory and submarine cable telegraphy are among the subjects covered.

This well illustrated book may be rated as recommended reading for the younger generation, recommended browsing for the older and an excellent reference source. ($20) — H. C. LIKEL

L. S. COGGESHALL, Assistant Vice President, International Communications

Telegraphy's Next 25 Years

The author was assigned this topic in connection with the attainment, by the American Institute of Electrical Engineers, of its 75th Anniversary. In fulfilling his assignment, the author's obvious recourse was to treat the Institute's fourth quarter-century as an extrapolation beyond the third one just ending. He therefore went back to 1934 and looked ahead.

THE MAN did not live in 1934 who could see today's developments. True, in single instances the germination was imminent and might have been subject to short-range forecast by specialists in 1934.

Submarine Telephone Cables

A transatlantic telephone cable was foreseen; the transoceanic cables, no. The first shallow-water submerged amplifier was destined to undergo initial development in England only four years later (1938) and be laid in the water in 1943. But a 1934 prediction to be worth anything would have had to foretell the picture of several completed 36-voiceband telephone cables laid in several oceans, some containing strings of half a hundred repeaters in series; the production of vacuum tubes which would not burn out and other circuit components whose characteristics would not vary when subjected to ocean-bottom pressures of tons to the square inch. A new dielectric, polyethylene, to replace gutta percha, would have had to be foretold, capable of standing up under electrical stresses manyfold greater than any heretofore experienced in ocean cable practice; the technique of riding and bucking the varying earth-currents prevalent in cables; the technology of broadband amplifier design, of the control of signal-noise ratios, and of coaxial cable transmission of high quality. These and many other developments of the 1935-50 period were not even hoped for in 1934, yet were essential to the cables laid in the 1950's.

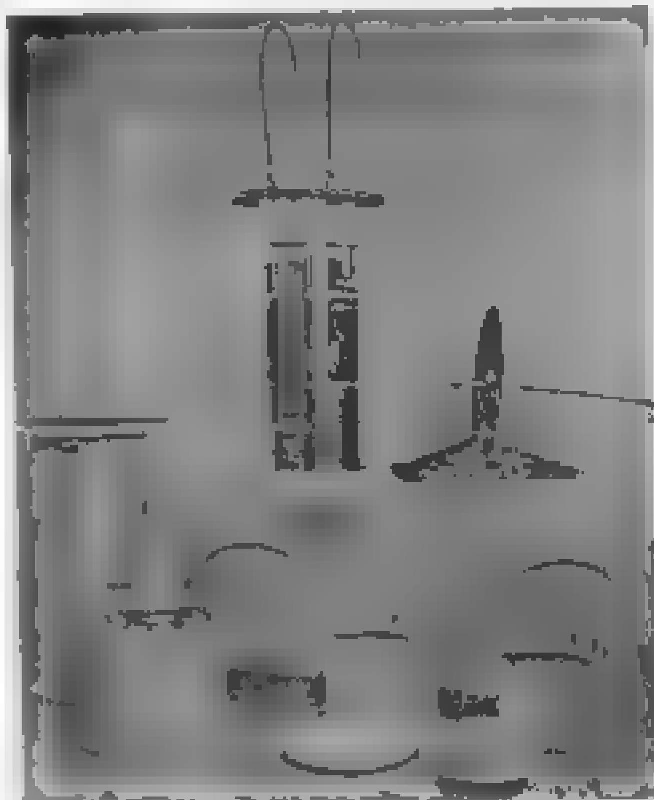


Photo R 10,077

Exploded view of first deep-sea cable amplifier, laid by Western Union in 1950, with vacuum tubes powered from shore over telegraph cable

High-Speed Binary Switching

If the posture of blindness is accurately descriptive of 1934 in relation to comparatively low-frequency submarine telegraph cables, it is doubly appropriate in relation to the other illustrations which accompany this article, for in all the apparatus depicted control currents circulate about at frequencies beyond all comprehension 25 years ago.

In the electronic revolution which took place during AIEE's third quarter-century, first place should probably be assigned to the linking together of the two-position switch with the binary system of computation. That, and the exten-

Essential substance of an article published in Electrical Engineering, Vol. 78, No. 5, May 1959.

sion of the use of switching to perform operations in logic, were inspired developments hardly to be foreseen by anyone—certainly not as to their present universal application—25 years ago. For by the use of the vacuum tube as the switching diode and later the transistor, direct current was found to be reversible as a single function of time at rates reaching up into the millions per second, and by orderly manipulation, information so handled could be stored and retrieved in microseconds of time.

In 1934, we had Hollerith mechanical card-punches, card sorters, and totalizers, which later became fundamental building blocks of digital computers as we know them today. At that time, also, we had analog computers of reasonable complexity performing sophisticated calculations; but no aching void for digitals was making itself felt—in fact the analog appeared fully capable of handling tricky mathematical problems that an adding machine could not handle. Then, in 1945, Howard Aiken at Harvard University asked the Telegraph Company for teleprinters, reperforators, tape transmitters, and transmitter-distributors, to be wired up as the input for his *Mark II* digital computer. The machines which were readily available ambled along at the standard speed of 65 words a minute. We telegraph people were delighted to see the venerable telegraphic pulse going to work in new overalls. Now, in 1959, the flip-flops work in the megacycles and the printers print a line at a time instead of a letter at a time. In 1934, we were blind to the problems, blind to the solutions. Counting on two fingers instead of ten? Manganese-zinc ferrite brains? What do you mean?

Television, Radar, and the Higher Frequencies

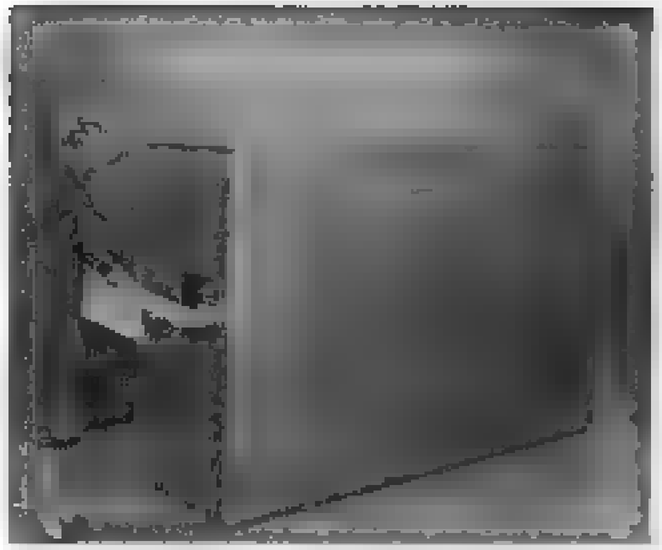
In 1934, the rudiments of television existed. Zworykin's iconoscope of 1923, Jenkins' and Baird's demonstrations of the early 1920's, and Farnsworth's dissector tube of 1928 all pointed to the fact that television eventually would come. But how? Where was all the radio bandwidth to come from? The top of the spectrum was 30 mc—if one went higher, what would one do for tubes? If mechanical scanning were to be employed, what would be the nature of the light valve? The problems themselves were elusive; their solution encountered roadblocks at every turn.

World War II became a most powerful stimulant to technical progress. Radar was virtually forced into acceptance. Mastery of its principles brought powerful new tubes and pulse techniques. It opened the band of very-high frequencies (vhf), hitherto closed. Ultra-high frequencies (uhf) fell next, and before the war was over, super-high frequencies (shf), or microwaves, were put to work. The broad bands thus opened to modulation cleared the way for commercial television. In the wake of television came researches on solid-state crystals, ceramic dielectrics, and other basic materials and concepts. The technical avalanche gathered force until today we have the experimental and working models depicted in our illustrations.

Government as a Major User of Facilities

No one would have guessed in 1934 the extent to which Government de-

In foreground is an International Business Machine read-out printer operating at 18,000 characters per minute as output of Type 705 computer



Stromberg-Carlson 15,000-characters-per-minute teleprinter, utilizing Charactron read-out tube and Haloid xerographic printer

mands for telegraphic facilities would have risen by the end of a war that would far outdo World War I, nor have judged that the unprecendented level of demand could possibly be sustained by the national wealth for 15 years afterward. That kind of money was not being spent in 1934—a year of financial depression. To illustrate: the U. S. Navy in 1934 leased but one landline circuit—a Morse duplex between Washington, D. C., and Boston, Mass., with drops en route. No voice leases, mind you. The Signal Corps had no landline leases. There was no Air Force, as such. Now, teleprinters had been in widespread commercial use in the United States since before World War I, yet the armed services had none. This is not to imply that the U. S. Army and Navy were without telegraphs. They had comprehensive radio installations in 1934 and long before—they had pioneered in radio. But for lack of appropriations, in 1934 they could not keep abreast of the commercial carriers in assimilating and using equipment then modern.

Then in succession came Hitler, the United States' preparedness program, Mussolini, Hirohito, Korea, and the Cold War. Billions were poured into electrical communication, including substantial amounts into radio and wire telegraphy and their techniques. Today "the shoe is on the other foot." Circuits of the most advanced types, supporting the armed services and a number of other governmental activities, are applied to the whole globe in a vast overlay. The most elaborate of all private wire systems are leased by the Government, comprehending electronically switched and error-protected teleprinters, data-handling systems between domestic and foreign points by radio and cable, extensive facsimile systems—everything "last word" and "biggest," as befits the job to be done.

A collateral result emerged as a central surprise element of the period 1939-59—one to which industry was quite oblivious at the outset; the emergence of the National Government as principal catalyst of technical progress, a position it holds today. Not only in size but in content, private laboratories and the universities undertake for the Government the most advanced research and development projects. Today the telecommunication carriers would be happy indeed if commerce and business could support on a nationwide scale the gilt-edged facilities and equipment that compose the Government networks. This reversal was certainly unforeseeable in 1934.

Communication "Blitz"

More so perhaps now than at other times predictions ought to be "hedged," out of deference to the uneasy possibilities of war of different degrees of intensity during the next 25-year period. Enormous sums have been expended during the cold war of the past dozen years upon defensive installations like early-warning radar networks and ground-environment systems. Communication laboratories have been participants in their design. Telegraphic information services of this type will be modernized and expanded during coming years. With two powerful nations poised in military stalemate, and with their missiles and aircraft in readiness but under an uneasy restraint dictated by a lively appreciation of the disastrous effects of attack, retaliation, local destruction, and global radiological havoc, the instant availability of intelligence of opposing threats and movements is of utmost import. Hence, instant and complex telegraphic information-gathering capa-

bilities, on a scale befitting World War III, will play a vital role in defense throughout most of the coming 25-year period.

There will be further refinements and modernization of automatic trajectory-sensing and gun-pointing or missile-launching military equipment, with increased information-handling capabilities and wider geographical deployment and coordination. This follows from the fact that the development of intercontinental ballistic missiles, with their support elements of telemetry, will continue to occupy a prominent position in the military arsenal.

Government Support of Research and Education

It has already been pointed out that by no means were all the developments technological that proved to be of most significance to electrical communication between 1934 and 1959, nor will they be during the next 25 years. A top position must be assigned to the extent to which the needs of Government will determine the direction and level of activity in the telegraph industry's laboratories and shops.

During the years before us higher education will also continue to receive Government support through research contracts, thus permitting the expansion of laboratory facilities beyond a point which would be economic if confined to faculty- and consultant-induced research work alone. In reflex, industry stands to benefit from the better educational preparation of the graduates whom it will hire, and from higher education's valuable contributions to the scientific press.

Volume of Government Communication

Apart even from its military arm, the Government, since 1941, has been one of the largest users of domestic and international telegraph communication facilities of all kinds. In 1959, it may be singled out as the largest contributing unit to telecommunication revenues. The record of the whole of the past quarter-century, from the first administration of F. D. Roosevelt in 1933 down through President Eisenhower, indicates a marked increase in rate of growth of Government personnel and appropriations year by year, as well as general acceptance, by both political parties, of the precept that only the Government is big enough to finance certain forms of business endeavor. While these trends have been deplored by experts, they have not been reversed in the give and take of practical politics. The pattern for the future may be assumed to have been set, with perpetually increasing Government activity as a source of income for the privately owned communication industry.

Regulation and Consolidations

The Communications Act of 1934 is just 25 years old. On the basis that a parallelism exists with the Interstate Commerce Commission (ICC), it is safe to predict that the Federal Communications Commission (FCC) will still be functioning in 1984. By then, the Congress may have been convinced that the privately owned telecommunication industry can render a better service, with proper public safeguards, under regulation than under wasteful competition. In any event its attitude will have become more liberal in permitting mergers which take into account the essential physical unities existing among: (1) telegraph and telephone, (2) wire and radio, and (3) domestic and international operations. The executive department and more agencies than exist today will be administering revised laws accordingly. Telegraph service will be better and more efficient. It will not be cheaper because of the circumstance that long-term inflationary money trends will have masked the lowering of real costs and prices.

Distinctions between Forms of Telecommunication

A feature of the past quarter-century has been the manner in which boundaries have been erased between wire and radio as means of transmission, and among the telegraph, telephone, television, and

radar forms of technology. This has been most marked in Europe, where all come under a common administration, for the most part. Even in the United States where the various modes are dispersed, the facts of life have had to be acknowledged. In 1934, there was no one to prophesy that within a few years most intercity trunk telegraph circuits would be shifted from railroad rights of way to telephone-telegraph carrier; nor that, between 1950 and 1958 almost a third of the Nation's long-distance circuits would be shifted from wires and multipair cables to microwave radio. Telephonic transmission by periodic sampling and phase-shifting of pulses thus sampled was an unknown art. Telegraphic transmission of nonlanguage signals, as a major growing sector of the business, was not even embryonic.

In the coming 25-year period, practical elimination of the remaining distinctions will have taken place. Encoded signals will be handled in "quanta of gray" as well as in black and white. Conversely, telephony will utilize pulse modulation methods that do not involve linear relationships of amplitude variations with sound-source intensities. In addition, there will be a leveling off of the remaining distinctions between the arts of wire and radio transmission, already apparent in 1959 in overseas telephony and in network television and sound broadcasting.

Competition between Communication and Transportation

Competition will be intensified between the delivery of information by physical transport and by electric transfer, as speeds of aircraft and other airborne transportation devices are developed—so much so that the capabilities of planes to transport motion-picture film, television tape, blueprints, and so on, will bear directly upon the feasibility of establishing telecommunication circuits, like television and facsimile, in specific locations and applications.

Public Telegram Service

The bread-and-butter public service of the Telegraph Company, rendered by means of branch offices, messengers, and telephone pickup and delivery, will follow recent asymptotic trends, and will yield to direct customer interconnection wherever volume traffic is concerned. Few telegrams will undergo more than one keyboard manipulation before delivery, and in most cases that one will take place on the filing customer's premises. Whether there will be storage en route will depend upon the outcome of the teetering balance between the cost of line channels and the cost of electronic storage and alternate-route switching in repeater and terminal equipment, with the odds in favor of the elimination of most storage. Storage, after a few years, will be in electromagnetic or electrostatic rather than in punched-tape, memories. Line switching, during most of the 25-year interval, will be by electromechanical relays, as at present.

Time-division multiplex, or still more efficient spectrum dividers will replace the start-stop, frequency-division carrier system now prevalent. Whatever the system, it will of necessity have to be self-synchronizing, self-phasing, and self-restoring after line interruptions—hence, completely adaptable to end-on-end section patching.

Voiceband Spectrum Utilization

Voice-frequency bands assigned to telegraphic (inclusive of data) communication will be more tightly stacked and more tightly packed than at present. Portions of bands heretofore allotted to the guarding of frequency-divided telegraph channels, from interference from adjacent channels, will be filled in. Useful purposes and means of retrieval will be found for the idle direction on half-duplex setups, now held in reserve for purposes of break-in and responses. Time now required for the transmission of the start-stop loading on teleprinter intelligence will be salvaged. The totality of the capacity of voicebands (or subbands, or groups of voicebands) will be apportioned among minute-to-minute applicants for service, not in standard 60-speed, 5-unit channels as at present, but packaged to suit each

applicant's momentary requirement of (a) total number of pulses per minute, and (b) the number of pulses (such as 5, 6, 7, 8 ...n) in each character. The processes used will begin with those now foreseeable: magnetic memory matrices, electronic counters occasionally synchronized, or varieties of sweep circuits used in television.

Terminal Handlings

The electrical connection of filers of telegrams with central telegraph offices will have reached the practical saturation point within the first half of the period under discussion. Otherwise, problems connected with local pickup and delivery will be present and no closer to solution in 1984 than in 1959. The same terminal difficulties which beset the Telegraph Company will continue to impede the prompt delivery of air mail, rocket mail, and any other kind of dispatch which cannot be delivered by electricity into the home or place of business.

Teleprinter Exchange Services

Telex in Europe, TWX and telex in the United States and Canada, and transoceanic telex (or tex) will continue to grow rapidly for several years before tapering off. Automatic switching will find preference over manual; keyboard, or director, switching over dial, and relay over electronic switching until such time as advanced spectrum-packing systems (mentioned previously under voiceband spectrum utilization) become standard. Concurrently with the adoption of devices for full band occupancy, electronic director switching will be introduced on a wide scale.

Director vs Dial Switching

The use of the dial for establishing through circuits already shows signs of being too slow and cumbersome for the switching of the future, and does not lend itself so readily to repeating and storage with language and data intelligence as does some form of director switching. The prediction is ventured that director switching will continue to be preferred in private telegraph network operations and will gradually replace manual switching and dials in teleprinter exchange and national public telegram networks. There will be exceptions in small countries.

Gentex vs Reperforator Storage

Gentex, the European system of switched direct interconnection of originating and delivering telegraph offices for the unit handling of each separate telegram, will prove uneconomical as to trunk utilization for public telegram services in geographically grand countries. The use of Gentex will grow in smaller communities. The disparity between costs of furnishing leased wire and unit telegram services, already great, will be magnified as time goes on. There will therefore be continued pressure put upon efficiency and all possible economies in the basic and well-patronized public message service.

Teleprinter Speeds

Keyboard dexterity has been pretty well tested out in industry and office practice in the past 50 years. Since 1934 (and before that date), no disposition has become apparent to set higher standards of keyboard output. Except to the extent that electric typewriters become more prevalent and contribute to the ease of keyboard manipulation, typing speeds are not likely to increase much. In the spurts typists commonly attain rates around 110 words per minute but they do not sustain them long. The present 65-wpm multiplexes fairly well dispose of the on-line output of such typists, but 60-speed start-stop arythmic keyboards do not. Considering the growing unification of electric typewriters with telegraph transmission, an estimate of the situation in 1984 is to the effect that 75-wpm on-line speeds will be more typical than 60-wpm, but that on-line operation will be less common than in 1959. Off-line preparation of signals will be by applique to the electric typewriter. Punched holes in tape will

Burroughs 3000-wpm teleprinter. Letters are formed electrostatically in 5-X-7-dot matrices, 72 on each line, a line at a time

have been superseded by a quieter means of storage—probably magnetic or electrostatic, of the type which will be evolved for the processing and transmission of other business office data. The run-off speeds of such data will be such as to occupy the entire voiceband (as we know it today) but of a protected-pulse type which all telegraph companies will offer before 1984.

Facsimile vs Teleprinters

No one would have foreseen in 1934 that by 1959 the Telegraph Company would have installed in business offices more facsimile machines than teleprinters for handling telegrams. Up until now, however, facsimile has not been used on the main trunks for telegrams, nor, except for weather maps, for any other wide usage. Telephotography is generally confined to news pictures, though adapted to transmission of printers' proofs and other uses.

As broadband telegraph facilities become cheap, the use of facsimile between and among the principal cities will grow. Switched private line facsimile systems will be established within the period under discussion, on the same basis as teleprinter exchanges, and will in part replace them. However, one system will not entirely replace the other before the end of the quarter-century, nor will facsimile and teleprinters be made compatible in a single system with automatic interchange accomplished by readers or translators.

Broadband Operation

Microwave beams, coaxial cables, and waveguides will set the pace for bandwidths measured in kilocycles and megacycles for telegraphic forms of modulation. In ocean cable technology, solid-state materials of the transistor type will reduce *emf* drops per repeater; and without undue strain on insulation will make it possible to accommodate television bandwidths on an intercontinental scale. Although there will be further successful attempts to exploit heterogeneities in the stratosphere, troposphere, and ionosphere, except for special applications these methods will yield to more stable means of communication. The same may be predicted for refraction from ionized meteor trails. However, during the next 25 years, enough artificial satellites will have been launched to provide reliable and constant communication, using them as passive reflectors. Solar-powered active repeaters will have entered into experimental use by the end of the period.

Overseas Radiotelegraphy

In the future, the high-frequency band of the radio spectrum will be more efficiently packed. This will be accomplished by means already referred to in the better utilization of each voiceband, plus wider utilization of single sideband techniques, and assignment of frequencies en bloc for the better coordination of transmitters. More microwave and waveguide landlines, more overseas radio links of the forward-scatter type, will be worked together, end to end. Latin America will preoccupy more communication attention than hitherto. High-frequency (short

wave) radiotelegraphy will find itself sharing loads with cables to a greater extent than in the recent past.

Language and Nonlanguage Information

Second only to Government, business will exert the pressures which will produce new forms of telegraphy, beginning in 1959. Business demands will take the form of a greater volume of information to be transmitted, at higher speeds, with greater accuracy, and at lower prices. The press will echo such requests and ask for additional concessions. These demands will be satisfied, at least in major part. A trend apparent in the recent past toward the offering, by business, of nonlanguage material for transmission will be more marked in the ensuing years. Such nonlanguage information will take two broad classifications: (1) the control of machines and batteries of machines in factories, associated by wire with central control offices; (2) direct and flexible couplings between business-machine units which are separated by distance, so contrived that after current data and stored data are consolidated, the computer will digest it and call attention to the items which have particular significance, subordinating the remainder.

Forms of Language Communication

Dispatches offered for transmission will take forms somewhat more complex than today's telegrams. There will be growing use of the business letter format as to size of paper, arrangement of text on the paper, and use of lower-case letters as well as upper-case. Some of these problems will be solved by facsimile. Demands will be felt for the coupling of communication facilities to electric typewriters, duplicators, and addressing machines. The use of multiple-address telegrams having a common text will increase.

Associated Techniques

Telegraphy will continue to draw heavily upon the resources of radio, telephony, photography; magnetic storage, of the drum, tape, core and other memory types; electrostatic storage, of the xerographic types; and the computer arts. It will also keep abreast of and accommodate itself to new developments in office machinery and processes.

RCA Ultrafax receiving terminal showing clock which timed the transmission, in 2 minutes 21 seconds, of 1047-page novel, "Gone with the Wind"

Miniaturization and Modular Construction

Though known previously, the printed circuit first assumed importance in the proximity fuze of World War II, which contained certain compact elements of television in miniature. Combined with tiny units of resistance, capacitance, and inductance; with two-sided plastic board construction; with printed contact-clip mounts; later with tiny transistors and diodes—the printed-circuit inserted assembly has become a bellwether of future electronics gear. It has already gained a foothold in computer, telephone, and telegraph equipment assemblies. The next few years will see its general employment as one solution to the problems of the maintenance of complex circuitry.

Telegraphy in Space

Before the end of 1970 there will be telemeter reports sent from the surface

of the moon under control of interrogation from the earth. During the next 25 years there will be more or less constant use of the moon as a passive reflector of radio waves between points on the earth's surface, but commercial use will be impeded by the moon's phases and the earth's horizons. There will be no public telegrams handled to an office on the moon, under filed tariffs, before June 1984. Men in space vehicles above the earth's atmosphere will communicate with the earth by radio-telephone by 1984.

* * * * *

Extrapolation of figures of physical growth items measured in numbers of messages or dollars is readily performed by plotting with a straightedge on logarithm paper, but had better not be carried beyond ten years. Projection into the future of a cell-dividing, fermenting, seething, mushrooming, burgeoning process like scientific discovery and its engineering applications, does not plot on graphs.

It is said to require 10 to 15 years for today's idea to become tomorrow's accepted actuality. If this be so, 25 years ahead is too far to hope to look. The existence of a problem may not be recognized as such until 10 years hence, the solution of which will find hardware in use a quarter-century from now.

Ivan Stoddard Coggeshall claims descent through ten generations of New England farmers from the original settlers of Plymouth, Mass., and Newport, R. I. He attended Worcester Polytechnic Institute, is an honorary Doctor of Engineering, a past President of the Institute of Radio Engineers, a past Chairman of the American Institute of Electrical Engineers' Communication Division, Assistant Vice-President, Western Union International Communications, and Commander, U. S. Naval Reserve (retired). He contributed the article "Radio" to *Encyclopaedia Britannica*, and the chapter "Wire Telegraphy" to the *Radio Engineering Handbook*. He represents the cable system in the Committee on Technical Publication.

Patents Recently Issued to Western Union

Phasing System

S. G. Allen, F. L. Currie, J. J. McManus

2,874,218—February 17, 1959

In a facsimile organization, a local phasing relay system slows the local motor by periodically interrupting the motor-driving circuit while continuously comparing the time interval between the incoming and local phasing pulses, with the interruption growing shorter as phase coincidence approaches, whereat a final full-length local pulse assures positive phasing. The method avoids failure to phase while running through phase coincidence, and is particularly adaptable for use with storage recorders or other situations where clutch phasing is undesirable.

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Fault Alarm Radio Repeater System

H. C. Likel

2,876,341—March 3, 1959

A fault alarm system for microwave repeater stations which signals to the terminal station the occurrence of various faults by sending permutations of pulses of a local oscillator fault tone frequency peculiar to the repeater station. In the case of loss of incoming carrier, the fault reporting system is arranged to re-establish it at the repeater. However, re-establishment should not occur until it has been determined at the terminal station that the carrier is in fact interrupted rather than faded to a low level but which still permits through communication between terminals. Carrier re-establishment, therefore, awaits receipt of a suitable recognition tone sent from the terminal station.

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Facsimile Scanning Drum Sheet Holder Apparatus

J. H. Hackenberg, R. J. Wise

2,878,095—March 17, 1959

A transparent wrapper for holding a message sheet against a facsimile scanning drum, releasably fastened at the leading edge to permit ready removal for cleaning, and with tensioned mounting for the trailing edge so as to hold even stiffened paper or cardboard copy solidly against the drum. After inserting the message, a short manual rotation of the drum causes automatic latching of the trailing edge of the wrapper into position under tension.

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Book Message Adapter with Number Checking

G. G. Light, H. A. Jansson

2,878,305—March 17, 1959

A book message, or multiple address, unit which may be of portable construction for use at different sending positions in telegraph switching centers. The outgoing line is switched alternately from a first transmitter which transmits from a tape bearing the sequence numbers and addresses, separated by end-of-address switching signals, to the second transmitter which sends from a tape loop the common message, terminated in an end-of-message switching signal. To provide certain safeguards, the switching signals comprise two characters and transfer of the source of transmitter stepping pulses cannot occur during generation of a stepping pulse. Also, for use at sending positions where it is not otherwise provided the unit includes a sequence number indicator with associated number check apparatus.

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Tungsten Concentrated Arc Lamp

W. D. Buckingham, R. C. Aldridge

2,882,434—April 14, 1959

A concentrated arc lamp comprising a tungsten ball formed at the end of a small tungsten wire as cathode and located directly adjacent to a light aperture of somewhat larger diameter in an anode member, the two being enclosed in a gas-filled glass envelope, preferably argon. The mounting wire, being at the rear of the ball, is shielded thereby from the aperture so that light therefrom cannot cause blurring or halo effects in the light beam.